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## Corrective Action Plan for
## Expanded Bioventing System
## Site SS-41
## Former Building 93 (Fuel Pumping Station No. 3)

Charleston Air Force Base
South Carolina

Prepared For

**Air Force Center for Environmental Excellence**
**Technology Transfer Division**
**Brooks Air Force Base**
**San Antonio, Texas**

and

**437 CES/CEV**
**Charleston Air Force Base**
**South Carolina**

April 1997

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# FINAL

# CORRECTIVE ACTION PLAN FOR EXPANDED BIOVENTING SYSTEM

## SITE SS-41

## FORMER BUILDING 93 (FUEL PUMPING STATION No. 3)

## CHARLESTON AIR FORCE BASE, SOUTH CAROLINA

**Prepared for**

**Air Force Center For Environmental Excellence**

**Brooks Air Force Base, Texas**

**And**

**437 CES/CEV**

**Charleston Air Force Base, South Carolina**

**April 1997**

**Prepared by:**

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**Cary, North Carolina 27513**

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## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AFB | Air Force Base |
| AFCEE | Air Force Center for Environmental Excellence |
| AOC | Area of Concern |
| AVG. | average |
| bgs | below ground surface |
| Bldg. | building |
| bls | below land surface |
| BTEX | benzene, toluene, ethylbenzene, xylenes |
| °C | degrees Celsius |
| CAP | corrective action plan |
| cfm | cubic feet per minute |
| COC | chemical of concern |
| $CO_2$ | carbon dioxide |
| CPT | cone penetrometer technology |
| DIA. | diameter |
| ES | Engineering-Science, Inc. |
| ft | feet (foot) |
| ft/ft | foot per foot |
| $ft^2$/day | feet squared per day |
| GC | gas chromatography |
| HDPE | high density polyethylene |
| HP | horsepower |
| ICP | Inductively Coupled Plasma |
| IRP | Installation Restoration Program |
| (k) | intrinsic permeability |
| mg/kg | milligrams per kilogram |
| MILCON | military construction |
| MP | monitoring point |
| MPA | monitoring point A |
| MPB | monitoring point B |
| MPC | monitoring point C |
| MPD | monitoring point D |
| msl | mean sea level |
| MW | monitoring well |
| O&M | operations and maintenance |
| $O_2$ | oxygen |
| PAH | polynuclear aromatic hydrocarbons |
| Parsons ES | Parsons Engineering Science, Inc. |
| P&ID | piping and instrumentation diagram |
| PID | photoionization detector |
| POL | Petroleum, Oil and Lubricant |
| ppm | parts per million |

| | |
|---|---|
| ppmv | parts per million by volume |
| PVC | polyvinyl chloride |
| RBC | risk-based concentration |
| RBCA | risk-based corrective action |
| RBSL | risk-based screening level |
| RCRA | Resource Conservation and Recovery Act |
| RFI | RCRA facility investigation |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| scfm | standard cubic feet per minute |
| SCH. | schedule |
| SSTL | site-specific target level |
| SVOC | semi-volatile organic compound |
| SWMU | solid waste management unit |
| TBC | to be considered |
| TCE | trichloroethene |
| TD | total depth |
| TKN | total Kjeldahl nitrogen |
| TPH | total petroleum hydrocarbons |
| TRPH | total recoverable petroleum hydrocarbons |
| TVH | total volatile hydrocarbons |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| UST | underground storage tank |
| µg/kg | microgram per kilogram |
| µg/l | micrograms per liter |
| VMP | vapor monitoring point |
| VOC | volatile organic compound |
| VW | vent well |

# SECTION 1

# INTRODUCTION

This plan presents the scope for an expanded bioventing system to provide *in situ* treatment of the remaining fuel-contaminated soils at Site SS-41, Former Building No. 93 (former Fuel Pumping Station No. 3), Charleston Air Force Base (AFB), South Carolina. The former Building No. 93 fuel pumping station was one of three fuel pumping stations that comprised part of the Charleston AFB fuel hydrant system. The entire fuel hydrant system, including the three fuel pumping stations, is collectively labeled as Site SS-41. The portion of Site SS-41 that will be treated by the proposed bioventing system is referenced as former Building No. 93 Fuel Pumping Station throughout this report. Former Building No. 93 Fuel Pumping Station is the only area at Site SS-41 that failed two risk-based screening tiers using the South Carolina Risk-Based Corrective Action (RBCA) guidelines for petroleum release sites. Therefore, former Building No. 93 is the only area of the Site SS-41 fuel hydrant system that is proposed for bioventing remediation under this Corrective Action Plan (CAP).

A one-year bioventing pilot study previously conducted at the former Building No. 93 Fuel Pumping Station had successful results in reducing fuel hydrocarbons in soils. Activities associated with the proposed system expansion will be performed by Parsons Engineering Science, Inc. (Parsons ES; formerly Engineering-Science, Inc.) for the Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division (ERT) under contract F41624-92-D-8036, 0017. The primary objectives of the bioventing system expansion are to:

- Deliver oxygen to additional areas of the site that have subsurface soils contaminated with fuel hydrocarbons that did not receive treatment during the one-year pilot study;
- Provide additional characterization data that can be used for site closure;
- Continue *in situ* remediation of fuel-contaminated soils by injecting atmospheric air into the soils to promote aerobic fuel biodegradation processes; and
- Sustain *in situ* aerobic fuel biodegradation until hydrocarbon-contaminated soils within the unsaturated zone are remediated to below regulatory-approved standards.

During November 1993, two vertical vent wells (VWs), four multi-depth vapor monitoring points (VMPs), and an air injection blower were installed on the west side of the former Building No. 93 underground storage tank (UST) system to conduct a bioventing treatability study. From July 1994 through August 1995, an extended bioventing pilot test was performed at the former Building No. 93 Fuel Pumping Station to determine if *in situ* bioventing would be a feasible cleanup technology for the fuel-contaminated soils in the vadose zone. The pilot-scale system was shut down in June 1995 and has not been operated since that time. As described in this CAP, a bioventing system expansion is planned to remediate unsaturated, fuel-contaminated soils remaining at the site. Further details on the pilot test procedures and results can be found in the *Draft Interim Bioventing Pilot Test Results Report for IRP Site SS-41, Former Flightline Fuel Pump House, Charleston AFB, South Carolina* (Engineering-Science, 1994).

Following the one-year pilot test, soil and soil gas sampling data confirmed significant fuel contaminant reduction in the pilot test treatment area. Laboratory results from soil gas samples showed significant reductions in total volatile hydrocarbons (TVH) and benzene, toluene, ethylbenzene, and xylenes (BTEX) concentrations in soil gas. Significant reductions in total recoverable petroleum hydrocarbon (TRPH) and BTEX compounds were also observed in soil. Soil BTEX concentrations were reduced to nondetectable levels and TRPH was reduced up to two orders of magnitude based on soil samples that were collected at the end of the one-year pilot test. BTEX compounds were still present in soil gas at the end of the one-year pilot test. The pilot test demonstrated that significant oxygen utilization and biodegradation are continuing in the pilot test area and that continued bioventing will promote additional fuel biodegradation in the soils. Further details of the pilot test results are presented in Section 3. The success of bioventing at this site supports the recommendation of an expanded (full-scale) bioventing system as the most economical approach of remediating the remaining hydrocarbon-contaminated soils at the site. Although the expanded bioventing system will remediate contaminated soil in the unsaturated zone, biodegradation of fuel hydrocarbons in vadose zone soils is expected to reduce BTEX loading in groundwater by removing the primary source of these contaminants. Benzene concentrations in shallow groundwater at former Building No. 93 currently exceed two South Carolina RBCA regulatory action levels (Parsons ES, 1996). Bioventing will be used to reduce the source of organic fuel compounds leaching to groundwater and as a means to further reduce potential risks associated with contaminants at this site.

Pilot test data have been used to design the full-scale bioventing system to remediate contaminated soils. The expanded system will consist of one of the existing VWs and up to nine additional vertical VWs (to be constructed) to deliver oxygen to the remaining areas having fuel-contaminated soils. Additionally, nine new multi-depth VMPs will be constructed to monitor contaminant reduction and oxygen influence adjacent to the new VWs. Additional soil and soil gas sampling will be conducted during these installations.

This document is divided into eight sections, including this introduction, and one appendix. Section 2 discusses site background and includes a discussion of existing characterization data. Section 3 provides the results of the bioventing pilot test conducted at the former Building No. 93 Fuel Pumping Station. Section 4 identifies the treatment area of the proposed expanded system; provides construction details of the expanded system; and recommends a proven, cost-effective approach for the remediation of the remaining hydrocarbon-contaminated soils at the site. Procedures for handling investigation-derived waste are described in Section 5, and Base support requirements are listed in Section 6. Section 7 provides key points of contact at Charleston AFB, AFCEE, and Parsons ES; and Section 8 provides the references cited in this document. A design package for the expanded bioventing system is provided in Appendix A. Regulatory comments to the Draft Final CAP and the response to regulatory comments are included in Appendix B.

# SECTION 2

# SITE BACKGROUND

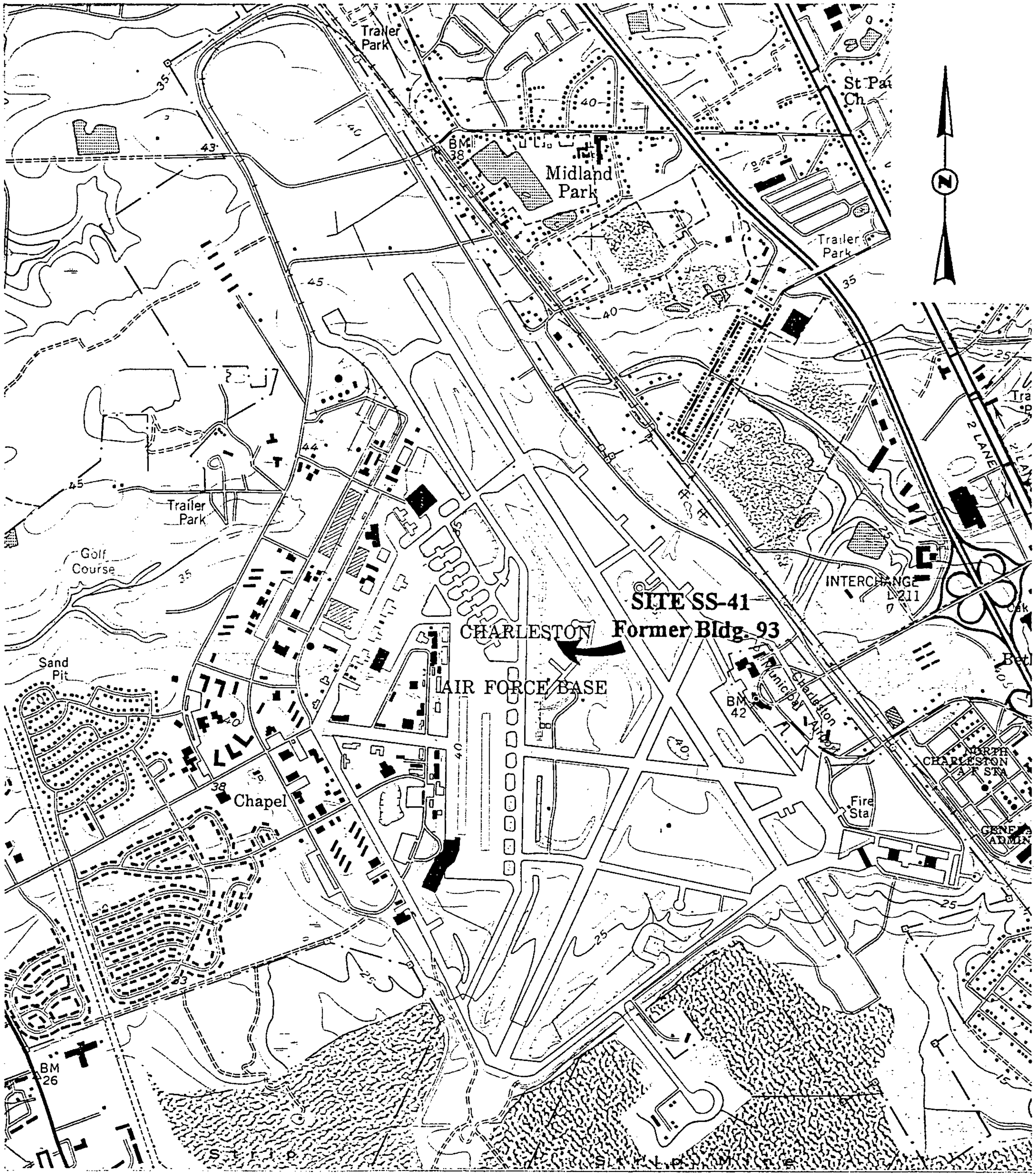
## 2.1 SITE SS-41 DESCRIPTION AND HISTORY

Jet fuel is received at the Charleston AFB Petroleum, Oil, and Lubricant (POL) Bulk Fuel Storage Depot (POL Fuel Depot) via an underground pipeline from an off-base source at the Defense Fuel Supply Point. Most of the jet fuel used for aircraft refueling is distributed through the base fuel hydrant system. The Charleston AFB fuel hydrant system begins at the POL Fuel Depot on the northwest side of the base and consists of a network of pipelines and fuel pumping stations that transfer jet fuel from the POL Fuel Depot to various fueling stations on the aircraft maintenance apron. Prior to its renovations, the fuel hydrant system included three flightline fuel pumping stations (two existing, one former), a primary 8-inch fuel transfer pipe connecting the POL Fuel Depot to the flightline fuel pumping stations, a network of piping headers and lateral fuel lines that transfer jet fuel to various fueling points on the aircraft maintenance apron, and ancillary drains, filters, waste fuel underground storage tanks (USTs) and valve pits. The base has designated the entire fuel hydrant system (exclusive of the POL Fuel Depot) as IRP Site SS-41 (Parsons ES, 1996). The general location of Site SS-41 and former Building No. 93 Fuel Pumping Station on Charleston AFB is shown on a topographic map in Figure 2.1. A detailed base map showing the locations of the liquid fuels pipeline, fuel hydrant system, and fuel pumping stations that comprise Site SS-41 is shown in Figure 2.2.

Existing or former fuel pumping stations included in the fuel hydrant system include those located at Building No. 99 (Fuel Pumping Station No. 1), Building No. 95 (Fuel Pumping Station No. 2), and former Building 93 (former Fuel Pumping Station No. 3). Each of the fuel pumping stations used six 50,000-gallon USTs for interim storage and transfer of jet fuel between the POL Fuel Depot and the aircraft parking apron fueling points. The base-wide *IRP RCRA Facility Investigation Work Plan, Charleston Air Force Base, South Carolina* developed by Halliburton NUS Corporation (1993) identified the fuel pumping station at former Building No. 93 (labeled as Building No. 97 in the 1993 RFI Work Plan) as Solid Waste Management Unit (SWMU) 146, and Building No. 99 as Area of Concern (AOC) B. Fuel pumping station No. 2 (Building No. 95) was not addressed in the RFI work plan and the subsequent *Draft RCRA Facility Investigation Report, Charleston AFB, South Carolina* (Halliburton NUS, 1995) that resulted from work done under that plan. Building No. 95 was included as part of the Site SS-41 fuel hydrant system site investigation conducted by Parsons ES (1996).

The base fuel hydrant system, aircraft parking apron, and portions of apron access Taxiway No. 4 are currently being renovated and expanded under a Navy Military Construction (MILCON) project. This construction project is being conducted in phases spanning several years. The new fuel hydrant system on the east side of the flightline drainage ditch has been completed and includes two above-ground fuel

Figure 2.1




Map Source: USGS (1958)
Ladson, South Carolina Quadrangle
(7.5 Minute Series)

2000' 1000' 0 2000'
Approximate Scale in Feet

Site Location Map

Site SS–41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

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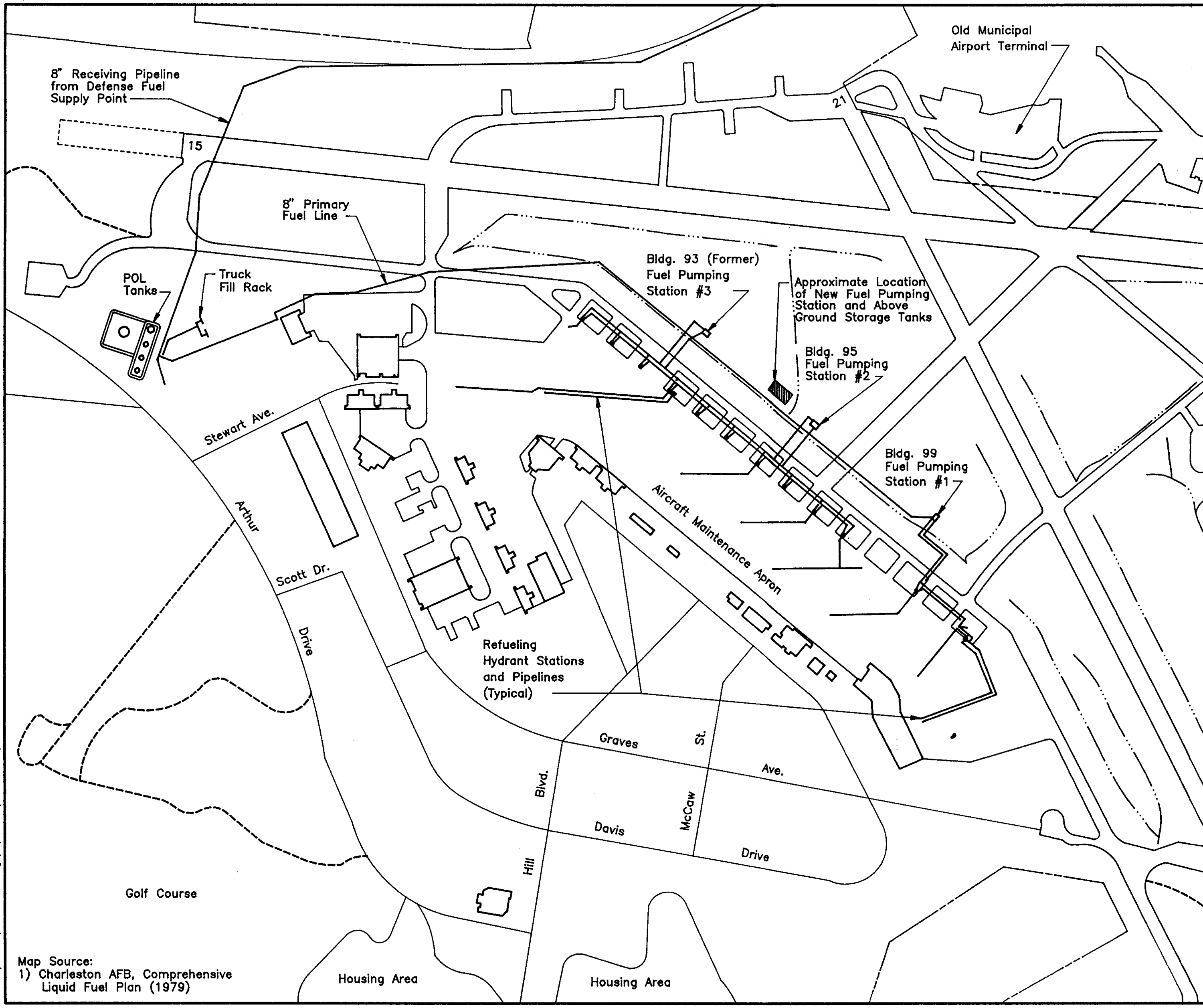
Figure 2.2




Notes:

1). This map shows the fuel hydrant system layout prior to renovations. New construction and modifications to the fuel hydrant system are not depicted, except as noted.

Map Source:
1) Charleston AFB, Comprehensive Liquid Fuel Plan (1979)

Site Map of Charleston AFB Fuel Hydrant System

Site SS-41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

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storage tanks and a new fuel pumping station. These new facilities are located on theflightline between Building No. 95 and former Building No. 93 fuel pumping stations (Figure 2.2). The former fuel pumping station and six USTs previously located at Building No. 93 were removed from service and demolished from July through October 1993 as part of this renovation project. An unknown quantity of fuel-contaminated soil was excavated and transported off-site during the UST removals at Building No. 93. The USTs, piping, buildings and related structures were not demolished at Fuel Pumping Station No. 2 (Building No. 95) and Fuel Pumping Station No. 1 (Building No. 99). Operation of these two older fuel pumping stations was discontinued following completion of the new above-grade storage tanks and fuel pumping station.

### 2.1.1 Description of Former Building No. 93 (Fuel Pumping Station No. 3)

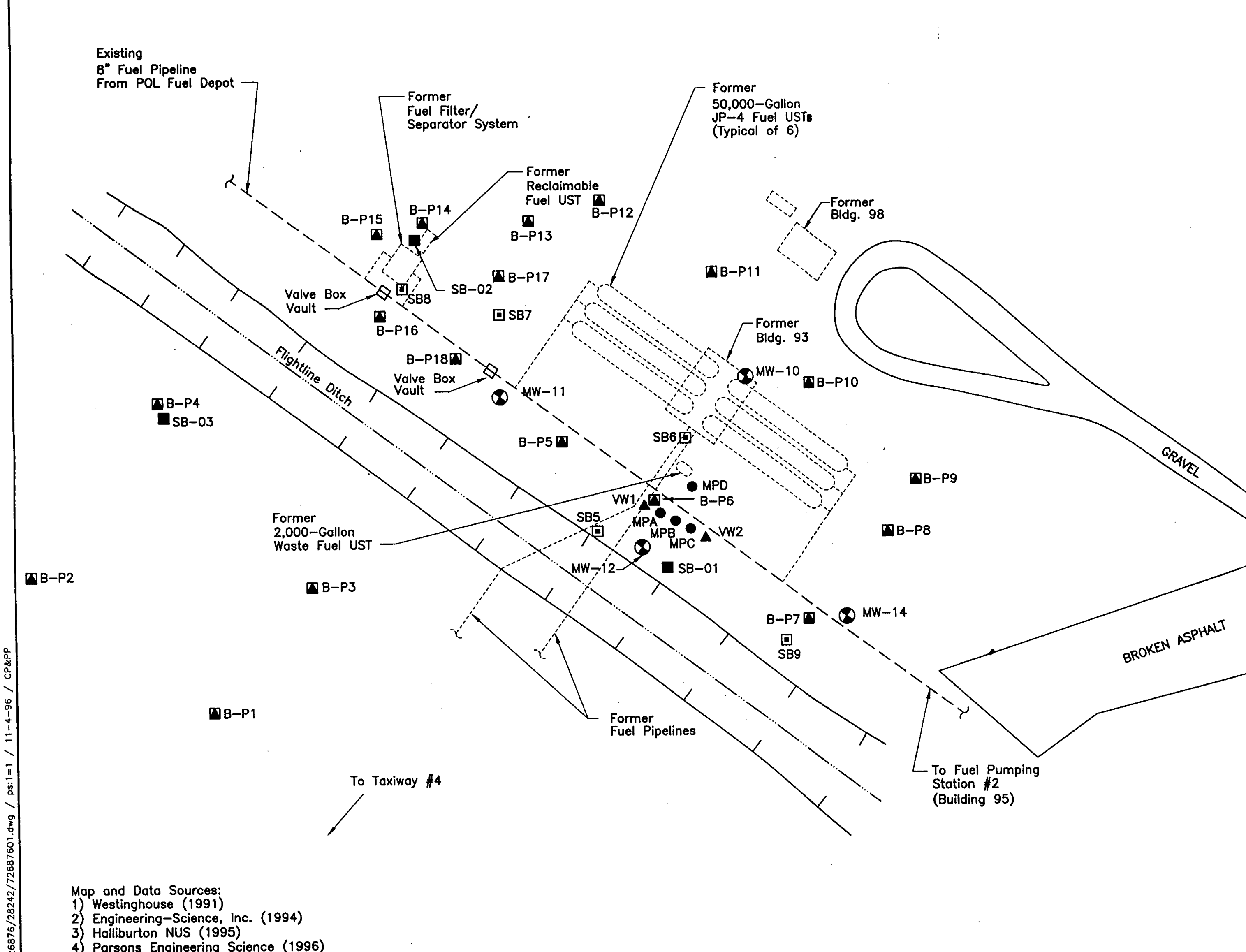
Former Building No. 93 (Fuel Pumping Station No. 3) was a metal canopy that partially covered the piping manifolds and six 50,000-gallon jet fuel USTs that were previously located at this site. Former Building No. 98 housed the adjacent fuel system controls for the fuel pumping station. Fuel Pumping Station No. 3 was one of three fuel pumping stations that received and stored jet fuel from the POL Fuel Depot and distributed the fuel to the hydrant system located on the aircraft apron. A system of air/fuel separators and fuel filters was located on a bypass of the 8-inch primary fuel distribution line about 100 feet north of the USTs. Two smaller USTs were also used at this fuel pumping station for waste fuel and reclaimable fuels. Figure 2.3 shows a detailed site map of the former Building No. 93 Fuel Pumping Station and adjacent facilities.

The USTs, buildings, filter systems and ancillary piping at Fuel Pumping Station No. 3 were removed from service and the site was demolished during the summer and fall of 1993. This work was conducted as part of the Navy MILCON fuel hydrant/apron renovation project. An unknown quantity of fuel-contaminated soil was excavated and removed from the site during the UST removals. The UST excavation was backfilled with clean soil and the upper three feet of the former tank pit was backfilled with construction-generated soil to bring the site to final grade. The 8-inch primary fuel line from the POL Fuel Depot remained intact and it is still in operation.

## 2.2 PREVIOUS INVESTIGATIONS

Geotechnical studies and environmental soil sampling were conducted by Westinghouse Environmental and Geotechnical Services, Inc. (Westinghouse) during August and September 1991 to support the Navy MILCON fuel hydrant system/aircraft apron renovation project. The scope of the Westinghouse investigation included 71 drilled geotechnical borings and 10 hand-augered borings installed around the aircraft apron, Taxiway #4, the POL Fuel Depot, and portions of the fuel hydrant system planned for demolition and/or renovation. Soil samples were collected from 53 of the borings for environmental sampling purposes. Eighteen of the environmental soil samples were collected in the vicinity of the former Building No. 93 Fuel Pumping Station (Figure 2.3). The soil samples were collected at the water table interface in

Figure 2.3




LEGEND

- MPA ● Permanent multi-depth vapor monitoring point.
- VW1 ▲ Bioventing vent well.
- MW-10 Existing groundwater monitoring well.
- B-P14 Westinghouse soil boring/sampling location (approximate).
- SB-01 ■ Halliburton NUS RFI soil boring/sampling location (approximate).
- SB7 Parsons ES 1995 soil boring/sampling location (approximate).

NOTES:

1. All above-grade and below-grade structures and USTs (except the primary 8" fuel pipeline) were removed in 1993.
2. All facility and appurtenance locations are approximated.
3. The locations of vent wells, monitoring wells, and soil gas points are accurate relative to one another. The locations of these features relative to former structures at the site (i.e buildings, tanks) are estimated.

60' 40' 20' 0 60'

Approximate Scale in Feet

Site Map – Former
Bldg. 93 Fuel Pumping Station

Site SS-41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

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each borehole. Soil samples were field-screened for organic vapors with a photoionization detector (PID) and were then submitted for laboratory analysis for benzene, toluene, ethylbenzene, and total xylenes (BTEX) compounds. BTEX constituents were detected in nine soil samples collected in the vicinity of Building No. 93. Fuel-related contamination was identified in soils on both sides of the flightline ditch in this area. No groundwater monitoring wells were installed during this investigation (Westinghouse, 1991). Section 2.4 discusses the results of the Westinghouse soil investigation at this site.

Additional soil sampling was performed at the former Building No. 93 Fuel Pumping Station in September 1993 by Coastal Engineering and Testing, Inc. These soil samples were collected prior to and during the UST removals associated with the Navy fuel hydrant system renovations. Soil borings were advanced around and beneath the USTs and associated piping in a grid pattern. Soil samples were analyzed for total petroleum hydrocarbons (TPH), BTEX and naphthalene. Additional analyses were performed on several of the samples for metals and jet fuel-fraction hydrocarbons. BTEX compounds and other petroleum-related constituents were detected in 47 of these samples (Charleston AFB, 1993).

After the Building No. 93 Fuel Pumping Station was demolished, a one-year bioventing treatability pilot study was initiated at the site by Parsons ES under contract to the Air Force Center for Environmental Excellence (AFCEE). A limited soil gas survey was performed to identify areas with fuel-contaminated, oxygen-depleted soils suitable for the bioventing study. Two vertical vent wells (VWs) , a regenerative blower, an electrical power supply, and four vapor monitoring points (MPA, MPB, MPC, and MPD) were installed at the site to conduct the test. Three soil boring samples were collected in unsaturated soils of the study area for BTEX and total recoverable petroleum hydrocarbons (TRPH) analyses. Three soil gas samples were collected from the vapor monitoring points (VMPs) for BTEX and total volatile hydrocarbons (TVH) analyses. Each of these environmental samples showed impact by petroleum-related compounds. Results of the initial bioventing testing are presented in the *Draft Interim Bioventing Pilot Test Results Report for IRP Site SS-41, Former Flightline Fuel Pump House, Charleston AFB, South Carolina* (Engineering-Science, Inc., 1994). The pilot-scale bioventing system began operating in July 1994 and operated for approximately one year. Details of the bioventing test are discussed in Section 3 of this report. Figure 2.3 shows the locations of pilot test installations relative to other features at the site.

In May 1994, Halliburton NUS Corporation conducted limited RCRA Facility Investigation (RFI) sampling in the vicinity of the former Building No. 93 Fuel Pumping Station (SWMU 146) according to the comprehensive base-wide RFI Work Plan. Three soil borings were advanced and sampled in the locations where soil contamination was detected during the Westinghouse investigation. Soil samples were analyzed for target volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, and TPH. Additionally, two surface water and two sediment samples were collected from the adjacent flightline ditch and analyzed for the same parameters. Results of this investigation are found in the *Draft RCRA Facility Investigation Report, Charleston AFB, South Carolina* (Halliburton NUS, 1995).

Parsons Engineering Science, Inc. (Parsons ES) conducted RFI sampling and a comprehensive site assessment for a large portion of Site SS-41 from August through November 1995. The study area was limited primarily to the fuel pipeline and pumping stations located on the east side of the flightline ditch. Portions of the fuel hydrant system located on the aircraft maintenance apron west of the ditch were not investigated due to the ongoing aircraft apron construction and renovation projects. A groundwater screening program was first conducted using direct-push cone penetrometer technology (CPT) sampling tools. A total of 34 groundwater samples were collected from 32 sampling points located along several thousand feet of the primary fuel pipe line. The groundwater samples were field-analyzed for BTEX compounds using a portable gas chromatograph (GC) instrument. A total of eight new groundwater monitoring wells and three piezometers were installed around the fuel pumping stations at Site SS-41 during this investigation. Four of these monitoring wells were installed around the former Building No. 93 Former Fuel Pumping Station (Figure 2.3). Additionally, a total of eleven soil borings were installed and sampled at Site SS-41, including seven in the vicinity of former Building No. 93 Fuel Pumping Station. Six surface water and six sediment samples also were collected in the flightline ditch and its larger tributary as part of this investigation. Results of this investigation are presented in the report *Site Assessment Report/Corrective Action Plan, Fuel Hydrant System (Site SS-41), Charleston Air Force Base, South Carolina* (Parsons ES, 1996).

## 2.3 SITE GEOLOGY AND HYDROGEOLOGY

A more detailed discussion of the site lithology and hydrogeology can be found in the following reports: *Draft Interim Bioventing Pilot Test Results Report for IRP Site SS-41, Former Flightline Fuel Pump House, Charleston AFB, South Carolina* (Engineering-Science, Inc., 1994); and *Draft RCRA Facility Investigation Report, Charleston AFB, South Carolina* (Halliburton NUS, 1995); and *Site Assessment Report/Corrective Action Plan, Fuel Hydrant System (Site SS-41), Charleston Air Force Base, South Carolina* (Parsons ES, 1996). Charleston AFB is located in the Lower Coastal Plain physiographic province of South Carolina. Sediments beneath the base are characterized as a thick sequence of interbedded sands, silts, and clays formed by fluvial and marine processes. These interbedded layers are grouped into regional formations and aquifers based on lithologic and water quality characteristics. Surficial soils around the base are generally sandy and highly permeable at shallow depths, but may contain zones of clay and organic deposits. The area is marked by low geomorphic relief.

The subsurface lithology was characterized at the former Building No. 93 Fuel Pumping Station during previous investigations. The shallow (residual) subsurface material was identified as part of the Ladson Formation, which consists of an undifferentiated fine to coarse-grained sand with lenses of silt, silty sand, clayey sand and clay stringers. In undisturbed soils around former Building No. 93, the upper five feet of soil was characterized as a clayey sand underlain by more permeable slightly silty fine sands (Parsons ES, 1996; Halliburton NUS, 1995). Similar lithology was described for the bioventing pilot study soil borings, with the exception of the nonresidual backfill that was placed over the former UST pit (Engineering-Science, Inc., 1994). Figure 2.4 shows a geologic cross section that was developed from soil borings installed during the bioventing pilot study. This figure also illustrates initial soil and soil gas sampling results for the pilot study.

The surficial aquifer occurs within the Ladson Formation. It is an unconfined (water table) aquifer, which is laterally extensive and is about 20 to 30 feet thick in the vicinity of Charleston AFB. The water table aquifer is recharged by infiltration of precipitation and discharge from the aquifer occurs primarily as seepage into surface water bodies. Downward migration into the underlying aquifers is limited by the confining Cooper Formation, which yields little or no water and forms a continuous regional aquitard beneath Charleston AFB (Parsons ES, 1996).

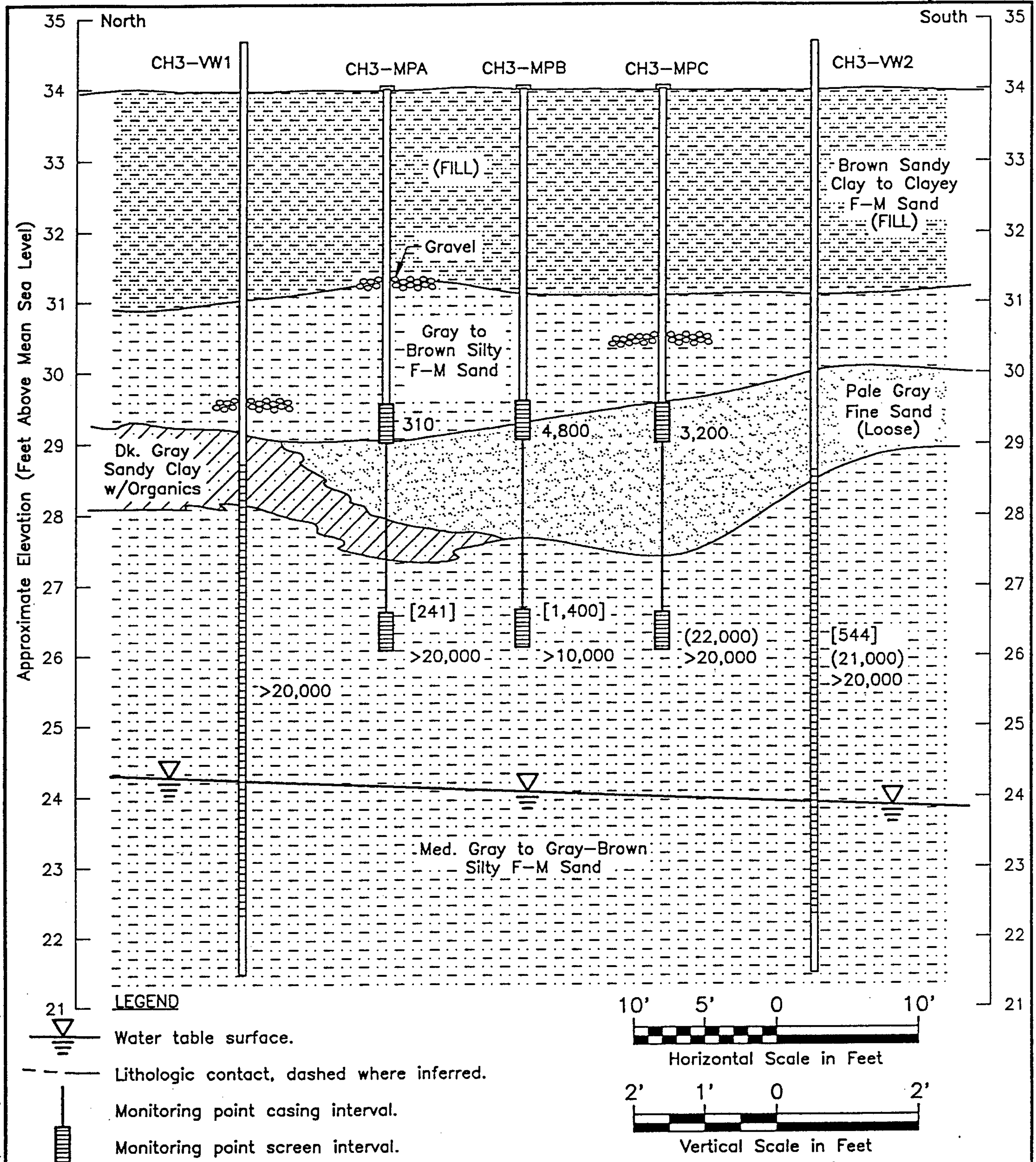
On a regional scale, depth to groundwater in the surficial aquifer ranges from near ground surface to approximately 13 feet below land surface (bls) and the water table surface tends to mimic local topography. Water table fluctuations of 1 to 6 feet per year are common in the surficial aquifer. Halliburton reported a water table depth of 5 feet bls during their investigation of the former Building No. 93 Fuel Pumping Station. Well gauging conducted by Parsons ES in June 1996 showed depths to groundwater ranging from approximately 8 feet bls (MW-11) to 12 feet bls (MW-12) at the former Building No. 93 site. The direction of groundwater flow within the surficial aquifer is subject to localized seasonal fluctuations but groundwater generally flows toward the south-southeast on a regional scale on this part of the base. Potentiometric maps developed from monitoring wells at Site SS-41 show localized groundwater flow directions toward a discharge point at the flightline ditch. On the east side of the flightline ditch at the former Building No. 93 Fuel Pumping Station site, shallow groundwater flows toward the west-southwest at a hydraulic gradient of 0.009 ft/ft (Parsons ES, 1996).

## 2.4 NATURE AND EXTENT OF SITE CONTAMINANTS

The primary contaminants at the former Building No. 93 Fuel Pumping Station site are petroleum hydrocarbons, which were detected in soil, groundwater, surface water and sediments near the site. Based on available sampling data as described below, the area of greatest soil and groundwater hydrocarbon contamination appears to be located in the vicinity of well MW-11 and around the two valve boxes on the 8-inch primary fuel pipe line that traverses the site (Figure 2.3). Various metals have also been detected in soils and groundwater above background levels.

Westinghouse advanced eighteen soil borings around Building No. 93 Fuel Pumping Station and collected soil samples for PID headspace screening and laboratory BTEX analyses. BTEX compounds were detected in the following nine soil samples: B-P4 through B-P7; B-P13 through B-P16; and B-P18. BTEX compounds were not detected in soil samples B-P17 and B-P8 through B-P12, which were collected generally upgradient (e.g. east and northeast) of the USTs and pipelines at Building No. 93 Fuel Pumping Station. The greatest concentration of BTEX was detected at soil boring

Figure 2.4




LEGEND

Water table surface.

Lithologic contact, dashed where inferred.

Monitoring point casing interval.

Monitoring point screen interval.

(21,000) Lab soil gas analytical results by EPA method TO–3, total volatile petroleum hydrocarbons (ppmv).

[544] Lab results, soil total recoverable petroleum hydrocarbons (mg/kg).

3,200 Field screening results, soil gas total volatile hydrocarbons (ppmv).

Note: Water table depth shown was measured on 11–16–93 (feet BLS).

Geologic Cross Section

Site SS–41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

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B-P14, located north of former Building 93 adjacent to the former fuel filter/separator system and reclaimable fuels UST (see Figure 2.3). The following soil BTEX concentrations were detected at B-P14: benzene (10 milligrams per kilogram [mg/kg]); toluene (8.8 mg/kg); ethylbenzene (13 mg/kg); and xylenes (50 mg/kg). Westinghouse reported the presence of "free product" near the fuel filters based on the observation of an oily sheen on saturated soil sample B-P14 (Westinghouse, 1991). Monitoring wells installed at the site subsequent to this investigation have not shown any free-phase product. The approximate locations of the 18 Westinghouse soil borings, including B-P14, are shown in Figure 2.3.

Soil sampling was performed by Coastal Engineering and Testing, Inc. in September 1993, prior to and during the UST removals at Building No. 93 Fuel Pumping Station. The samples were collected around the former USTs and analyzed for various parameters including TPH, BTEX, and naphthalene. Several additional samples were analyzed for jet fuel fraction hydrocarbons and RCRA metals. BTEX compounds were detected in 47 of the soil samples. The highest detected benzene concentration was 7.4 mg/kg at a depth of 4 feet bls and the highest naphthalene concentration was 37.2 mg/kg. Detectable soil TPH concentrations ranged from 2.4 mg/kg to 1,180 mg/kg. Jet fuel hydrocarbon concentrations ranged from less than 10 mg/kg to 24,000 mg/kg. Detected RCRA metals and the highest concentration include: arsenic (20 mg/kg), barium (110 mg/kg), cadmium (1 mg/kg), chromium (10 mg/kg), lead (30 mg/kg), mercury (0.1 mg/kg), selenium (20 mg/kg), and silver (4 mg/kg). These results were not available in a final published report and were provided by the base as preliminary data results (Charleston AFB, 1993).

Three soil samples were collected and analyzed as part of the bioventing pilot study at the former Building No. 93 Fuel Pumping Station. These sample locations are designated as VW2, MPA, and MPB on Figure 2.3. The sample depths were above the water table and averaged 7.5 to 8 feet bls. Benzene was not detected in any of the soil samples, although ethylbenzene, toluene, and xylenes were detected. TRPH concentrations ranged from 241 mg/kg to 1,400 mg/kg. Three soil gas samples were quantitatively analyzed for BTEX and TVH. Benzene was not detected in soil gas, however TVH concentrations of 21,000 parts per million by volume (ppmv) were detected at both VW2 and MPC (Engineering-Science, Inc. 1994).

The three soil samples collected by Halliburton NUS in 1994 showed various types and concentrations of contaminants. All three samples showed detections of metals, including arsenic, barium, beryllium, chromium, lead, manganese and vanadium. Two of the soil samples had elevated field headspace organic vapor readings ranging from 500 ppm (SB-01) to 1,300 ppm (SB-02). The highest concentrations of fuel-related hydrocarbons were detected in soil sample SB-02 , which was collected at a shallow depth (0-1 feet bls) near the former fuel filters. This sample had a TPH concentration of 647 mg/kg and detections of numerous SVOCs, including 2-Methylnaphthalene at 5 mg/kg (Halliburton NUS, 1995). The approximate locations of Halliburton NUS soil borings SB-01 and SB-02 are shown in Figure 2.3.

Seven soil borings (SB-3 through SB-9) were advanced and sampled around the former Building No. 93 Fuel Pumping Station during the site assessment conducted by

Parsons ES in 1995. The highest concentrations of fuel-related VOCs detected in soils included the following: benzene (1.7 micrograms per kilogram [μg/kg]); ethylbenzene (17 μg/kg); isopropylbenzene (2 μg/kg); naphthalene (25 μg/kg); tert-butylbenzene (2.7 μg/kg), toluene (2.7 μg/kg); m,p-xylene (110 μg/kg); o-xylene (56 μg/kg); 1,2,4-trimethylbenzene (34 μg/kg); 1,3,5-trimethylbenzene (43 μg/kg); and p-isopropyltoluene (6.1 μg/kg). The highest TPH concentration detected at the site was 44 mg/kg as jet fuel. These results were all obtained from soil boring SB-03 (sample depth 4-6 feet bls), which is the soil boring for well MW-11 (Figure 2.3). Various chlorinated hydrocarbons also were detected in low concentrations in soils at the site, including the compounds 1,1,2,2-tetrachloroethane and 1,1,1-trichloroethane. Trichloroethene (TCE) was detected in all of the soil samples collected at this site, ranging in concentration from 4.2 μg/kg at SB-09 to 18 μg/kg at SB-06. In three of the soil borings (SB-7, SB-8, and SB-9) no VOCs were detected with the exception of TCE. SVOCs were detected in only two of the seven soil borings sampled at the site. In soil boring SB-6, benzo(b)fluoranthene was detected at 170 μg/kg and pyrene was detected at 210 μg/kg. In soil boring SB-7, detected SVOCs included: benzo(a)anthracene (790 μg/kg); benzo(a)pyrene (850 μg/kg); benzo(b)fluoranthene (1400 μg/kg); benzo(ghi)perylene (800 μg/kg); benzo(k)fluoranthene (500 μg/kg); chrysene (1,000 μg/kg); fluoranthene (1,800 μg/kg); indeno(1,2,3-cd)pyrene (870 μg/kg); phenanthrene (990 μg/kg); pyrene (1,900 μg/kg); and bis(2-ethylhexyl) phthalate (530 μg/kg) (Parsons ES, 1996).

Groundwater at the former Building No. 93 Fuel Pumping Station contains various fuel-related VOCs and SVOCs. Data from an October 1995 groundwater sampling event detected concentrations of VOCs and SVOCs only in monitoring well MW-11. The following compounds were detected in groundwater during that sampling event: benzene (86 micrograms per liter [μg/l]); ethylbenzene (25 μg/l); naphthalene (2.3 μg/l); toluene (84 μg/l); m,p-xylene (98 μg/l); n-butylbenzene (1.8 μg/l); o-xylene (90 μg/l); p-isopropyltoluene (2.2 μg/l); phenol (13 μg/l); and bis (2-ethylhexyl) phthalate (2.1 μg/l). In addition, TPH as JP-4 was detected at a concentration of 4,800 μg/l in well MW-11. A later sampling event in November 1995 showed detections of fuel-related compounds in monitoring wells MW-11 and MW-12 at this site. In MW-11, BTEX compounds, bis (2-ethylhexyl) phthalate and TPH were detected. Bis (2-ethylhexyl) phthalate and TPH were detected in well MW-12 during this later sampling event (Parsons ES, 1996).

A risk evaluation was conducted by Parsons ES in as part of the Site SS-41 site investigation. The purpose of this evaluation was to assess potential risks to human health and the environment resulting from exposure to on-site media. The methodologies used in this assessment include South Carolina Department of Health and Environmental Control (SCDHEC) guidance for Risk-Based Corrective Action (RBCA) for Petroleum Releases (SCDHEC, 1995) for indicator chemicals associated with petroleum-related contamination and USEPA Region IV screening methodology (USEPA, 1995) for those constituents not included in the South Carolina RBCA guidance. Using the RBCA evaluation for groundwater chemicals of concern (COC), benzene concentrations in monitoring well MW-11 exceeded the Tier 1 risk-based screening level (RBSL) and the Tier 2 assessment Site-Specific Target Level (SSTL).

For subsurface soils, the polynuclear aromatic hydrocarbon (PAH) compounds benzo(a)anthracene, benzo(b)fluoranthene, and chrysene exceeded the RBCA guidance Tier 1 RBSLs for direct contact and/or leachability to groundwater. Two soil COCs (benzo(a)pyrene and arsenic), which are not covered by RBCA, also exceeded the USEPA Region IV industrial scenario risk-based concentrations (RBCs) and/or background levels. Additionally, the organic compounds p-isopropyltoluene, n-propylbenzene, benzo(ghi)perylene and phenanthrene were detected in soil but these compounds do not have regulatory RBCs for soil. Using the RBCA guidance, no Tier 2 SSTLs were exceeded for soils.

# SECTION 3

# BIOVENTING PILOT TEST RESULTS

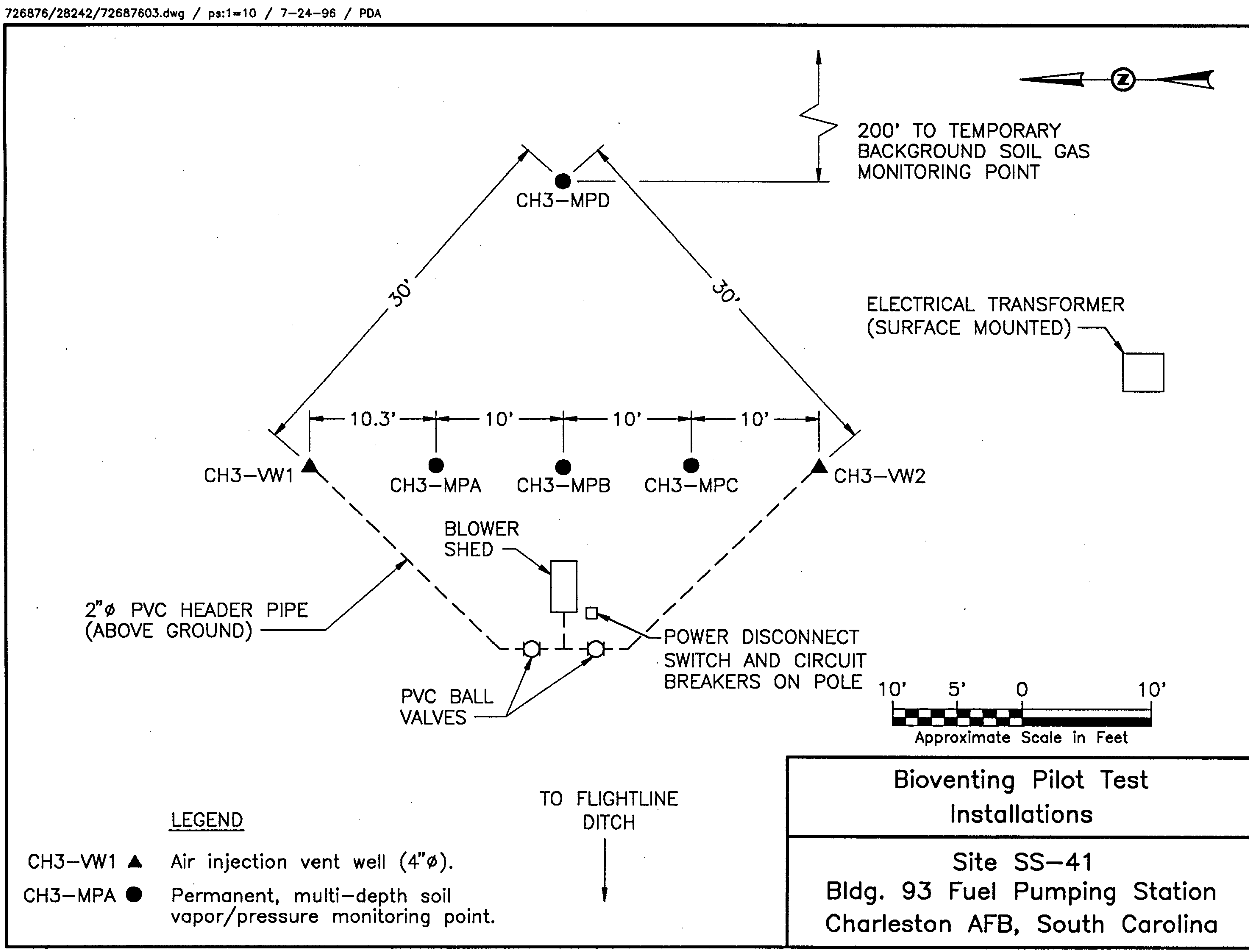
A bioventing pilot test was conducted by Parsons ES at the former Building No. 93 Fuel Pumping Station to determine if *in situ* bioventing would be a feasible cleanup technology for the fuel-contaminated soils within the unsaturated zone. The initial air permeability and respiration tests associated with the bioventing pilot study were completed in November 1993. A one-year extended testing phase was later performed from July 1994 through August 1995. The objectives of the bioventing pilot test were to:

- Assess the potential for supplying oxygen throughout the contaminated soil profile;
- To determine the rate at which indigenous microorganisms will degrade petroleum hydrocarbons when stimulated by oxygen-rich soil gas at this site; and
- To evaluate the potential for sustaining these rates of biodegradation until hydrocarbon contamination is remediated below regulatory-approved standards.

The bioventing blower was shut down on June 30, 1995 to perform final soil and soil gas sampling and it has not resumed operation since that time. Because bioventing has been demonstrated to be a feasible technology to remediate hydrocarbon-contaminated soils at this site, the pilot test data were used to design a full-scale bioventing system to remediate additional areas at the site (Section 4). Operational data from the pilot test indicate that installation of up to nine additional vent wells will remediate a larger area of soils and eventually achieve "no further action" levels using RBCA regulatory standards for fuel-related hydrocarbons in soils. Reduction of organic contaminants in vadose zone soils and at the capillary fringe is expected to facilitate groundwater remediation indirectly because the contaminant source area will be addressed by the bioventing system. As a result, bioventing will be used as a presumptive remedy to reduce the source of organic fuel compounds in groundwater.

## 3.1 INITIAL PILOT TEST CONFIGURATION

Two vertical air injection vent wells (VWs), four multi-depth pressure/vapor monitoring points (VMPs) and a blower and air injection piping system were installed at the former Building No. 93 Fuel Pumping Station site from November 15-22, 1993. Electrical power was later installed by the base and the blower began operating in July 1994. This pilot test system was installed under the direction of Parsons Engineering Science, Inc. (formerly Engineering-Science, Inc.). A limited soil gas survey was conducted at the site prior to these installations to define fuel-contaminated areas with oxygen-depleted soil gas that would be suitable for the bioventing pilot test. Figure 3.1 depicts the bioventing pilot test configuration with the locations of the VMPs, the two vertical VWs, and the air injection blower and piping. The following sections describe in more detail the design, installation, and testing of the bioventing pilot test system used at the site.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200' TO TEMPORARY BACKGROUND SOIL GAS MONITORING POINT
CH3-MPD
30'
30'
ELECTRICAL TRANSFORMER (SURFACE MOUNTED)
10.3'
10'
10'
10'
CH3-VW1
CH3-MPA
CH3-MPB
CH3-MPC
CH3-VW2
BLOWER SHED
2"ø PVC HEADER PIPE (ABOVE GROUND)
POWER DISCONNECT SWITCH AND CIRCUIT BREAKERS ON POLE
PVC BALL VALVES
10' 5' 0 10'
Approximate Scale in Feet
TO FLIGHTLINE DITCH
LEGEND
CH3-VW1 ▲ Air injection vent well (4"ø).
CH3-MPA ● Permanent, multi-depth soil vapor/pressure monitoring point.
Bioventing Pilot Test Installations
Site SS-41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

Figure 3.1

### 3.1.1 Air Injection Vent Wells

Two air injection VWs were installed at the site for interim testing and long-term use during the bioventing study. The VWs were located within oxygen-depleted, fuel-contaminated soils identified during the soil gas survey. The VWs were aligned parallel to the fuel transfer pipeline in a north-south orientation. The VWs were also placed at a sufficient distance from the adjacent drainage ditch to prevent air short-circuiting along the edge of the ditch. Figure 2.3 shows the location of the VWs relative to other site features. Figure 3.1 shows the VWs and VMP detailed layout for the bioventing system.

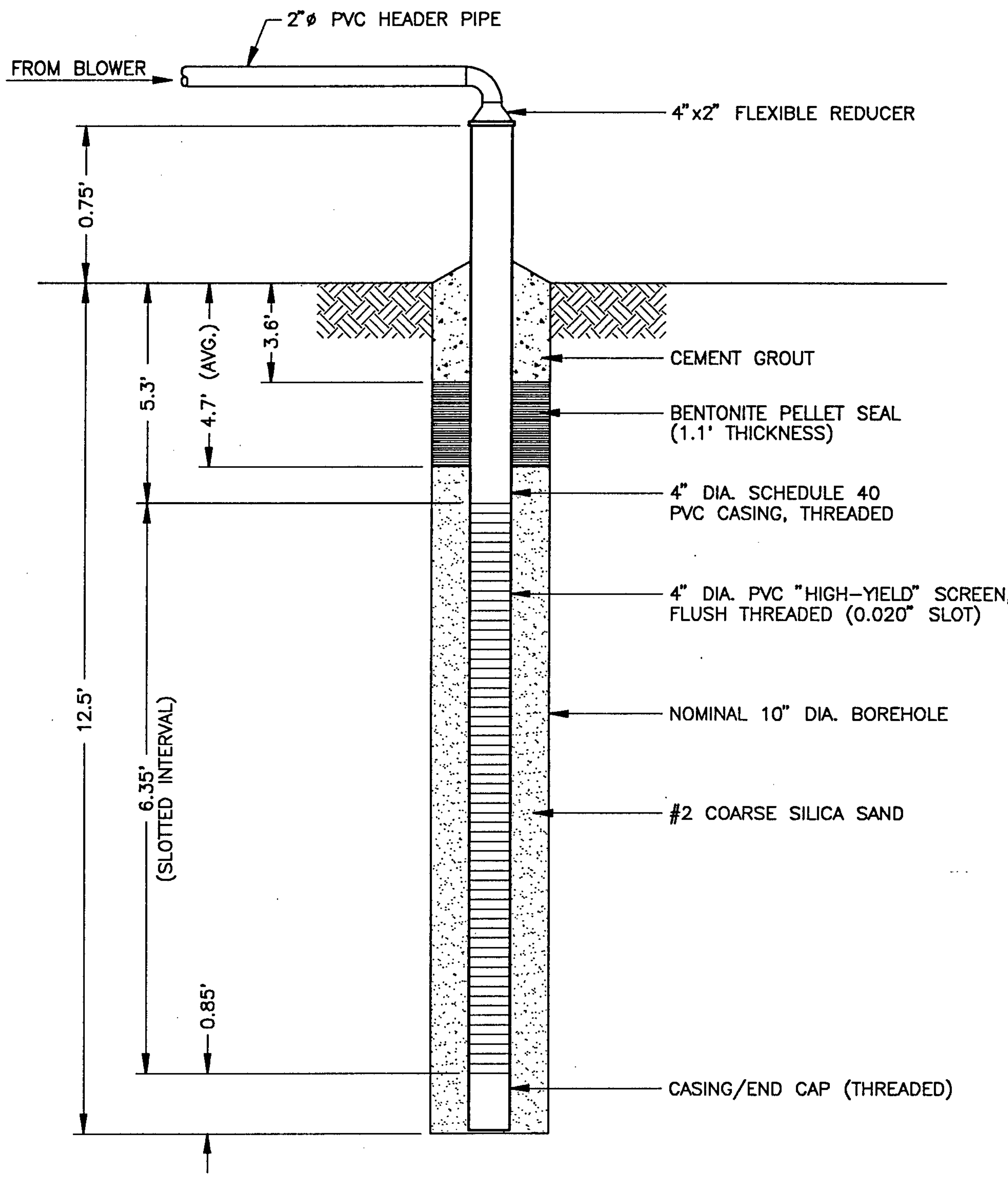
The VWs were installed using a mobile drill rig advancing 10-inch diameter hollow stem augers. Soil samples were collected at approximate 2-foot intervals using both a split spoon sampling device and hand augers advanced through the hollow stem augers. Each borehole was advanced to 12.5 feet bgs. Soil lithologies were characterized and several of the samples from each borehole were screened for TVH using a portable field hydrocarbon analyzer. Using the TVH field screening results to establish relative contamination, one soil sample from vent well VW2 was submitted for laboratory analyses. Lithologic descriptions were made during VW installations.

Both VWs were constructed using 4-inch diameter PVC screens and casing installed in the boreholes. Groundwater was encountered at a depth of approximately 10 feet bgs during the VW installation. The bottom of the VW screen was installed beneath the water table to a total depth of 11.65 feet bgs to ensure that an adequate length of screen would be exposed in the unsaturated zone if the water table declines. Approximately 5 feet of screen was exposed above the water table at each VW at the time of installation.

Figure 3.2 shows a typical construction schematic for the VWs. Two threaded screen sections (one 2.5-foot and one 5.0-foot section) were used to construct each VW. Both sections consist of 0.020-inch slotted "high-yield" screens. The "high-yield" screens have a greater number of slots per linear foot than do conventional monitoring well screens, thereby reducing pressure losses associated with the screen and improving air exchange between the VW and the formation. Each VW was completed with a PVC casing stickup above ground surface. As-built construction and operating details for the air injection VWs are provided in the *Draft Interim Bioventing Pilot Test Results Report for IRP Site SS-41, Former Flightline Fuel Pump House, Charleston AFB, South Carolina* (Engineering-Science, 1994).

### 3.1.2 Vapor Monitoring Points

Four multi-depth VMPs were installed in the pilot test area. Three of the VMPs (MPA, MPB, MPC) were installed on 10-foot centers on an axis between the two VWs, as depicted in Figure 3.1. The fourth VMP (MPD) was installed 30 feet from both VWs toward the east. Boreholes for the VMPs were advanced using a stainless steel hand auger. Soil samples were collected from the boreholes at regular intervals and screened in the field for TVH concentrations. Soil samples from two of the VMPs were submitted for laboratory analyses.




NOTES:

1. Drawing is not to scale.
2. Well construction schematic is typical for both vent wells, CH3–VW1 and CH3–VW2.
3. Vent wells were installed on 11/15/93.
4. Water table surface was 10.28' below ground surface in CH3–VW2 on 11/16/93.

As–Built Schematic of Pilot Test Vent Wells

Site SS–41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

PARSONS ENGINEERING SCIENCE, INC.

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Each of the VMPs was constructed using 0.5-inch threaded PVC screen and casing. The top of each VMP was fitted air tight with a gas ball valve equipped with a hose barb. Two VMPs (MPA and MPB) were equipped with thermocouple probes to measure soil temperature. All four VMPs were similarly constructed as multi-depth monitoring points. The screened intervals were placed from 4.5 to 5.0 feet bgs and from 7.5 to 8.0 feet bgs in each VMP borehole. These screened intervals are expected to remain above the water table, with the possible exception of unusually-high water table conditions. Figure 3.3 shows the typical construction schematic for the pilot test VMPs. Construction details listing the depths and screened intervals of each VMP also are shown in Figure 3.3.

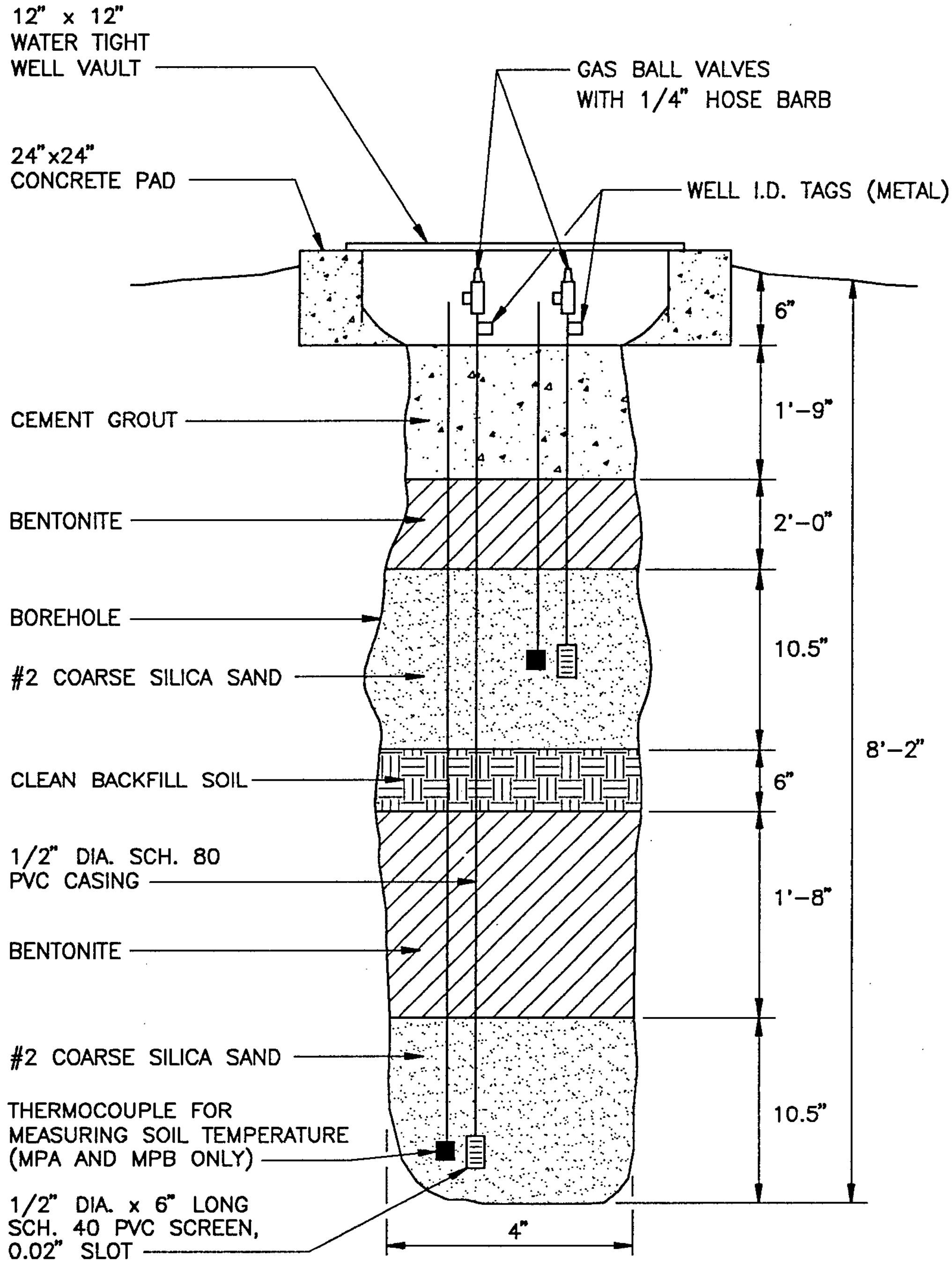
A temporary background VMP, designated as CH3-BG-4, was installed in clean soils 200 feet east of the VWs using a retractable soil gas probe. The background VMP was used to monitor background soil gas conditions not affected by hydrocarbon contamination. Soil gas oxygen ($O_2$) concentration at CH3-BG-4 was 19.2 percent, indicating that abiotic and/or nonfuel $O_2$ uptake is not a major factor at this site. The background soil $O_2$ concentration observed at this site is consistent with background $O_2$ concentrations found at other bioventing sites on the base.

### 3.1.3 Blower Unit Installation and Operation

A 1-horsepower Gast® Model R4110-2 regenerative blower unit was installed at Building No. 93 Fuel Pumping Station for extended pilot test operations. The initial air permeability tests were conducted using a Gast® Model 2067 rotary vane compressor powered by a portable generator, since electrical line power was not available at that time. The Gast® regenerative blower was installed in a weatherproof enclosure and is energized by 230-volt, single-phase, 30-amp circuit from a nearby circuit breaker and disconnect box provided by the base. Air is supplied by the blower through a 2-inch diameter above ground PVC manifold and header pipes that are attached to the VWs using flexible PVC 4"x2" reducers. Each segment of the manifold was equipped with a PVC ball valve so that the air flow to each VW can be controlled individually (Figure 3.1).

The blower began operation for the one-year bioventing pilot test on July 1, 1994. Before starting the extended test, water levels were measured in the VWs to determine the unsaturated screen length available for air injection. The extended bioventing test began by first starting the blower with the manual pressure relief valve fully open and then slowly closing the valve to begin blowing pressurized air into the VWs. Air injection for the system was initially set at an operating pressure of 40 inches of water and a total system air flow rate of approximately 24 cubic feet per minute (cfm). Both VWs had almost equivalent operating pressures, although it was later determined that most of the air flow into the soils was occurring through VW2.

The air flow and injection pressures into the VWs were reduced significantly in January 1995 by opening the manual pressure relief valve even further to bypass more of the air to the atmosphere. The system was then set to operate for the remaining six months at a total system pressure of 36 inches of water (34" at VW1; 32" at VW2) and a total flow rate of 11 cfm. Of the total air flow at that system pressure, only 2.7 cfm




DRAWING IS NOT TO SCALE

MONITORING POINT CONSTRUCTION DETAILS

| Monitoring Point No. | Screened Intervals (FT) | Thermocouple Depths (FT) |
|---|---|---|
| CH3-MPA | 4.5-5.0/7.5-8.0 | 5.0/8.0 |
| CH3-MPB | 4.5-5.0/7.5-8.0 | 5.0/8.0 |
| CH3-MPC | 4.5-5.0/7.5-8.0 | NA |
| CH3-MPD | 4.5-5.0/7.5-8.0 | NA |

Note:
1. Construction schematic is typical for all monitoring points.

As-Built Schematic of Vapor Monitoring Points

Site SS-41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

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PARSONS ENGINEERING SCIENCE, INC.

of air could be injected into VW1, while the remaining air flow (8.3 cfm) preferentially went into VW2. Attempts to inject more air into VW1 resulted in high air pressures that exceeded the performance capacity of the blower. These operating results demonstrated that VW2 performed better than VW1 during the pilot test and it provided most of the air flow that oxygenated soils at the site.

The long-term operating air injection rate varied from approximately 11 to 24 cfm at 36 to 40 inches of water pressure for the two-well system. Air injection pressures varied slightly during the test based on soil moisture and water table position. Measurable soil pore pressures were maintained at distances greater than 30 feet under these operating conditions.

## 3.2 PILOT TEST PROCEDURES AND RESULTS

During installation of the VWs and VMPs, soil samples were collected for laboratory analyses to establish baseline TRPH and BTEX concentrations and various inorganic and physical parameters. Soil gas samples were also collected for laboratory analyses from one VW and two VMPs to establish baseline soil gas TVH and BTEX concentrations. Results of these baseline soil and soil gas analyses are summarized in Table 3.1.

Prior to initiating air injection, all VMPs were purged until $O_2$ levels had stabilized and then baseline soil gas indicators of $O_2$, carbon dioxide ($CO_2$), and TVH concentrations were sampled using portable gas analyzers as described in the bioventing technical protocol document (Hinchee et al., 1992). In contaminated soils, microorganisms had depleted soil gas oxygen concentrations to less than 1 percent. In contrast, the temporary background VMP, outside the area of contamination, had 19.2 percent oxygen at a depth of 4 feet. Table 3.2 summarizes the initial soil gas chemistry measured with field instruments prior to beginning the pilot test.

### 3.2.1 Baseline and Final Soil Hydrocarbon Concentrations

As described in previous investigations, soil hydrocarbon contamination at the former Building No. 93 Fuel Pumping Station was encountered primarily around the former USTs and fuel filters. During the bioventing pilot test field installations, contaminated soils were identified based on visual appearance, odor, and organic vapor headspace field screening results. Using these criteria to identify potential contamination, fuel-impacted soils were encountered in all of the boreholes installed during the pilot study. Soils in the pilot study areas had moderate to strong hydrocarbon odors and produced elevated organic vapor headspace readings. Groundwater encountered during the VW installations also contained fuel odors.

During VW and VMP construction in November 1993, the greatest concentrations of soil contamination appeared to occur in the deeper soils below a depth of 5 feet bls. Soil samples for laboratory analysis were collected using split spoon samplers and hand augers. Soil samples collected from the soil borings were placed in air-tight plastic bags and screened for total volatile hydrocarbons (TVH) using a portable hydrocarbon analyzer. The TVH headspace screening results were used to determine the relative contamination of each sample and as a guide for selecting samples for laboratory

## TABLE 3.1

## INITIAL SOIL AND SOIL GAS ANALYTICAL RESULTS
## SITE SS-41
## FORMER BUILDING No. 93 FUEL PUMPING STATION
## CHARLESTON AFB, SOUTH CAROLINA

| Analyte (Units)[a] | Sample Location-Depth (feet below ground surface) | | |
|---|---|---|---|
| **Soil Hydrocarbons** | VW2-8 | MPA-7.5 | MPB-7.5 |
| TRPH (mg/kg) | 544 | 241 | 1,400 |
| Benzene (mg/kg) | <1.5[c] | <1.5[c] | <1.2[c] |
| Toluene (mg/kg) | 23 | 46 | 14 |
| Ethylbenzene (mg/kg) | 2.8 | <1.5[c] | 2.9 |
| Xylenes (mg/kg) | 19 | 17 | 16 |
| **Soil Gas Hydrocarbons** | VW2 | MPC-8 | MPD-8 |
| TVH (ppmv) | 21,000 | 21,000[b] | 17,000 |
| Benzene (ppmv) | <0.52[c] | <0.75[c] | <0.51[c] |
| Toluene (ppmv) | <0.52[c] | <0.75[c] | <0.51[c] |
| Ethylbenzene (ppmv) | 5.9 | 5.3[b] | 3.4 |
| Xylenes (ppmv) | 8.1 | 11.5[b] | 9.9 |
| **Soil Inorganics** | VW2-8 | MPA-7.5 | MPB-7.5 |
| Iron (mg/kg) | 930 | 280 | 370 |
| Alkalinity (mg/kg as $CaCO_3$) | <47[c] | <46[c] | <46[c] |
| pH (units) | 4.5 | 5.1 | 4.6 |
| TKN (mg/kg) | 40 | 100 | 42 |
| Phosphates (mg/kg) | 40 | 40 | 30 |
| **Soil Physical Parameters** | VW2-8 | MPA-7.5 | MPB-7.5 |
| Moisture (% wt.) | 15.3 | 14.6 | 13.9 |
| Gravel (%) | 0.0 | 0.0 | 0.0 |
| Sand (%) | 71.1 | 81.8 | 82.2 |
| Silt (%) | 11.4 | 11.2 | 8.3 |
| Clay (%) | 17.5 | 6.9 | 9.6 |

[a] TRPH = Total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram; TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume; $CaCO_3$ = calcium carbonate; TKN = total Kjeldahl nitrogen.

[b] Results averaged with duplicate sample.

[c] Not detected above method detection limits.

## TABLE 3.2

## INITIAL SOIL GAS CHEMISTRY
## SITE SS-41
## FORMER BUILDING No. 93 FUEL PUMPING STATION
## CHARLESTON AFB, SOUTH CAROLINA

| Sample Location | Depth (ft) | $O_2$ (%) | $CO_2$ (%) | TVH (ppmv)[a/] | TRPH (mg/kg)[b/] | Temp. (°F) |
|---|---|---|---|---|---|---|
| MPA | 8.0 | 0.1 | 9.2 | >20,000 | 241 | 63.9 |
| MPB | 8.0 | 0.3 | 7.7 | >20,000 | 1,400 | 64.5 |
| MPC | 8.0 | 0.0 | 8.0 | >20,000 | NS | - |
| MPD | 8.0 | 0.0 | 12.2 | 8,000 | NS | - |
| MPA | 5.0 | NM[c/] | NM[c/] | NM[c/] | NS | 60.2 |
| MPB | 5.0 | 0 | 7.9 | 4,800 | NS | 61.3 |
| MPC | 5.0 | NM[c/] | NM[c/] | NM[c/] | NS | - |
| MPD | 5.0 | NM[c/] | NM[c/] | NM[c/] | NS | - |
| Background | 4.0 | 19.2 | 0.5 | NS | NS | - |
| VW-2 | 8.0 | 1.0 | 8.1 | >20,000 | 544 | - |

a/ GasTech™ hydrocarbon analyzer field screening results, parts per million by volume.
b/ Laboratory results, total recoverable petroleum hydrocarbons (milligrams per kilogram).
c/ NM = Not measured due to VMP construction water in well screen.
NS = Not sampled.

analyses. Soil samples for laboratory analyses were collected from the boreholes for MPA at a depth of 7.5 feet, from MPB at a depth of 7.5 feet, and from VW2 at a depth of 8 feet. Each of the soil samples were analyzed for the following parameters: TRPH; individual BTEX compounds; iron; alkalinity; total Kjeldahl nitrogen (TKN); pH; phosphates; percent moisture; and grain size distribution. The results of these baseline analyses are presented in Table 3.1.

After completing one year of bioventing testing, confirmation soil samples were collected at the original sampling locations and analyzed for TRPH, BTEX and moisture. The purpose of the final sampling was to provide a qualitative indication of reduction in contaminant mass. A significant reduction of TRPH and BTEX compounds was observed in the soils after one year of bioventing. Soil TRPH was reduced in all sampling locations by one to two orders of magnitude after one year. Soil BTEX reduction was more significant with two to three orders of magnitude reduction. BTEX compounds in soil were reduced at all sampling locations to below detection limits after one year of bioventing treatment. A comparison of the baseline and final soil sampling results from the one-year pilot test is provided in Table 3.3.

### 3.2.2 Baseline and Final Soil Gas Hydrocarbons

During the pilot test, initial and final soil gas samples were collected using SUMMA® canisters for laboratory analyses of TVH and BTEX compounds. Baseline laboratory soil gas samples were collected from MPC (8-foot depth), MPD (8-foot depth) and VW2 prior to the pilot test startup. Analytical results indicated initial soil gas TVH concentrations ranging from 17,000 ppmv at MPD to 21,000 ppmv at MPC. Initial soil gas BTEX concentrations were relatively low, ranging from no detection (ND) to 12 ppmv for individual BTEX compounds. The aromatic compounds benzene and toluene were not detected in any of the baseline soil gas samples.

After one-year of bioventing, final soil gas samples were again collected from the same monitoring points for laboratory analyses for TVH and BTEX compounds. These results were compared to results of soil gas samples collected prior to bioventing air injection to provide a qualitative indication of reduction in soil gas hydrocarbon mass. A significant reduction of TVH and BTEX compounds (one to three order of magnitude) was observed in soil gas at two sampling points after one year of bioventing. A comparison of initial and final soil gas sampling results is provided in Table 3.3. The bioventing blower was turned off and the soil gas was allowed to equilibrate for approximately 30 days prior to collecting the final soil gas laboratory samples.

### 3.2.3 Air Permeability Test

A soil air permeability test was conducted at the site on November 20, 1993 according to bioventing protocol procedures. Using a rotary vane compressor pump, air was injected into VW2 at a flow rate of 6.3 standard cubic feet per minute (scfm) and a pressure of 27.5 inches of water. Pressure responses were measured at multiple depths in the surrounding VMPs using either a digital manometer or Magnehelic® pressure gauges.

## TABLE 3.3
## INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
## SITE SS-41 (FORMER FUEL PUMPING STATION, BLDG. No. 93)
## CHARLESTON AFB, SOUTH CAROLINA

| Analyte (Units) [a] | Sample Locations-Depth (feet below ground surface) | | | | | |
|---|---|---|---|---|---|---|
| | VW2 | | MPC-8 | | MPD-8 | |
| Soil Gas Hydrocarbons | Initial [b] | 1-Year [c] | Initial [d] | 1-Year | Initial | 1-Year |
| TVH (ppmv) | 21,000 | 17 | 21,000 | 700 | 17,000 | 23,000 |
| Benzene (ppmv) | < 0.52 | 0.021 | < 0.75 | 0.50 | < 0.51 | 25 |
| Toluene (ppmv) | < 0.52 | 0.16 | < 0.75 | < 0.014 | < 0.51 | 38 |
| Ethylbenzene (ppmv) | 5.9 | 0.010 | 5.4 | < 0.014 | 3.4 | 70 |
| Xylenes (ppmv) | 8.1 | 0.010 | 12 | 2.0 | 9.9 | 96 |
| | VW2-8 | | MPA-7.5 | | MPB-7.5 | |
| Soil Hydrocarbons | Initial [e] | 1-Year [f] | Initial | 1-Year | Initial | 1-Year |
| TRPH (mg/kg) | 544 | < 9.98 | 241 | 89.5 | 1,400 | 159 |
| Benzene (mg/kg) | < 1.5 | < 0.050 | < 1.5 | < 0.050 | < 1.2 | < 0.050 |
| Toluene (mg/kg) | 23 | < 0.050 | 46 | < 0.050 | 14 | < 0.050 |
| Ethylbenzene (mg/kg) | 2.8 | < 0.050 | < 1.5 | < 0.050 | 2.9 | < 0.050 |
| Xylenes (mg/kg) | 19 | < 0.130 | 17 | < 0.130 | 16 | < 0.130 |
| Moisture (%) | 15.3 | 14.6 | 14.6 | 13.6 | 13.9 | 15.3 |

[a] TVH=total volatile hydrocarbons: ppmv = parts per million, volume per volume;
TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

[b] Initial soil gas samples collected on November 17, 1993.

[c] Final soil gas samples collected on August 8, 1995. Blower system was shut down approximately 30 days prior to soil gas sampling to allow soil gas to come to equilibrium with soils.

[d] Result averaged with duplicate sample.

[e] Initial soil samples collected on November 15 and 16, 1993.

[f] Final soil samples collected on August 9, 1995.

Vent well VW1 was also fitted air tight and monitored for pressure responses during the test. Air was injected for 130 minutes until relative steady-state pressures were achieved and maintained at the VMPs.

Soil gas permeabilities were calculated using the HyperVentilate® model and the dynamic pressure response data. Soil permeability (k) values obtained for the shallow VMPs ranged from 2.13 darcys (MPB-5) to 5.90 darcys (MPA-5). In the deeper VMPs, the permeability values ranged from 2.07 darcys (MPC-8) to 5.01 darcys (MPD-8). These soil permeability values are reasonable for a fine-to-medium sand soil matrix. Initial air permeability testing indicated that soil pressure responses can be induced at distances exceeding 40 feet. Approximate steady-state pressure at VW1 (radius = 40.3 feet) was 3.99 inches of water. A soil permeability value of 4.15 darcys was derived by the steady-state pressure solution, which agrees well with results obtained using the dynamic pressure response equations. It is likely that soil pressure responses were created at distances of 40 to 50 feet from the VW during the test.

### 3.2.4 Bioventing Oxygen Influence

The depth and radius of $O_2$ increase in the subsurface resulting from air injection into a VW during pilot testing is the primary design parameter for full-scale bioventing systems. Optimization of full-scale and multiple VW systems requires pilot testing to determine the volume of soil that can be oxygenated at a given flow rate and VW screen configuration. Oxygen concentrations in soil gas were measured several times during the pilot test to determine the short-term and long-term influences of air injection on soil gas oxygen concentrations. Table 3.4 summarizes the baseline (pretest) soil gas conditions and the changes in soil gas $O_2$ levels that occurred during the short-term air permeability test and after six months of air injection. Table 3.4 also presents soil gas $O_2$ levels that equilibrated at the site after the pilot test blower had been shut down for 37 days in preparation for the final (one-year) respiration tests and sampling event.

Because the air permeability test was conducted immediately after completing the *in situ* respiration tests, the soil gas $O_2$ levels were slightly elevated above their baseline, oxygen-depleted condition during the air permeability test. During the air permeability test, air was injected into VW2 at a flow rate of 6.3 scfm for 130 minutes. Soil gas composition ($O_2$, $CO_2$, TVH) was measured at the VMPs near the end of the air permeability test to monitor the influence of injected air (oxygen) outward from the VW and other relative changes in soil gas. After 98 minutes of air injection into VW2, $O_2$ had increased from 4.0 percent to 14.5 percent at MPC-8 and from 3.5 percent to 7.2 percent at MPB-8. After 130 minutes of air injection, $O_2$ had increased from 1.6 percent to 3.0 percent in MPA-8. Slight $O_2$ increases (0.4 percent to 0.9 percent) were also measured in monitoring point MPD-8 at this time. These data indicate that during the short-term air permeability test, $O_2$ was transported outward greater than 30 feet from VW2 at the given test air flow rates (6.3 scfm) and injection pressures (27.5" water). Table 3.4 summarizes these results.

## TABLE 3.4
## INFLUENCE OF AIR INJECTION ON OXYGEN CONCENTRATIONS
## SITE SS-41
## FORMER BUILDING No. 93 FUEL PUMPING STATION
## CHARLESTON AIR FORCE BASE, SOUTH CAROLINA

| Monitoring Location | Depth (feet) | Distance from VW2 (feet) | Initial $O_2$ (percent) | Permeability Test Final $O_2$ [a/] (percent) | 6-Month Test $O_2$ [b/] (percent) | Post-Test $O_2$ [c/] (percent) |
|---|---|---|---|---|---|---|
| MPA | 5 | 30 | NM | 9.8 | 21.0 | 0.5 |
| MPB | 5 | 20 | 0.0 | 6.0 | 21.0 | 0.0 |
| MPC | 5 | 10 | NM | 17.8 | 21.0 | 0.0 |
| MPD | 5 | 30 | NM | NS | 18.5 | 0.0 |
| | | | | | | |
| MPA | 8 | 30 | 0.1 | 3.0 | 21.0 | 0.0 |
| MPB | 8 | 20 | 0.3 | 7.2 | 20.3 | 1.0 |
| MPC | 8 | 10 | 0.0 | 14.5 | 20.8 | 0.0 |
| MPD | 8 | 30 | 0.0 | 0.9 | 19.3 | 0.0 |
| | | | | | | |
| VW1 | 5.3-11.6 | 40.3 | 0.0 | NS | 21.0 | 0.0 |
| VW2 | 5.3-11.6 | 0 | 1.0 | 21.0 | 21.0 | 4.2 |

[a/] Oxygen concentrations observed at end of air permeability test performed in November 1993.

[b/] Oxygen concentrations observed at beginning of 6-month respiration test (9 January 1995).

[c/] Oxygen concentrations observed after system shut down for 37 days (7 August 1995).

[d/] NM = Not measured due to water in VMP screen.

NS = Not sampled

Soil gas $O_2$, $CO_2$ and TVH levels were measured during the extended bioventing pilot test after six months of operation to determine the long-term operating effectiveness of the system. Generally, soil gas measurements collected during extended testing are better indicators of the long-term influence of air injection on soil gas conditions. Table 3.4 shows the results of soil gas indicators that were field measured after six months of air injection. These results showed good horizontal and vertical distribution of $O_2$ in subsurface soils at distances greater than 30 feet from the VWs. All of the deeper VMPs showed greater than 19% oxygen in soil gas after six months of operation. The shallow screened intervals of the VMPs (5-foot depths) also showed soil gas $O_2$ concentrations greater than 20% , with the exception of MPD-5, which had 18.5% soil gas $O_2$. Air injection rates were reduced significantly after evaluating these results.

Soil gas measurements were not collected while the system was operating near the end of the one year pilot test. However, soil gas measurements were collected at the end of the pilot test after the blower had been shut down for 37 days and prior to conducting final respiration tests. At that time, soil gas $O_2$ levels again had decreased to 1% or less in all VMPs, indicating continued biorespiration activity in the soils.

### 3.2.5 In-Situ Respiration Rates

*In situ* respiration testing was conducted to determine the biodegradation rates of indigenous bacteria in contaminated subsurface soils. Table 3.5 shows the results of three *in situ* respiration testing events conducted as part of the bioventing pilot test. These testing events are listed as the initial, 6-month, and 12-month respiration tests.

The initial *in situ* respiration tests were conducted before turning on the air injection blower for pilot-scale operation. These initial tests were performed by injecting air (oxygen) mixed with about 4% helium into the VMP screened intervals for a 16.5-hour period using small 1 scfm air pumps. Changes in soil gas composition over time were measured after the air injection ceased. Soil gas $O_2$, $CO_2$, TVH and helium were measured for 45 hours following air injection.

Air injection into the VWs during the extended pilot study efficiently oxygenated soils within the test area. As a result, respiration tests conducted at the end of six months were performed by turning off the blower system and monitoring $O_2$, $CO_2$, and TVH levels in the VMPs. The bioventing system had been turned off for 37 days prior to conducting the one-year respiration tests to allow soil gas to reach equilibrium. As a result, the one-year respiration tests were conducted in the same manner as the initial respiration tests by injecting air into the individual VMPs using small air pumps.

The fuel biodegradation results determined by *in situ* respiration testing at this site are presented in Table 3.5 for the three testing events. Fuel biodegradation rates decreased in the VMPs between the initial and 1-year respiration tests for which there are data for comparison. The respiration data collected during the six-month tests (January, 1995) showed much lower fuel biodegradation rates compared to the initial and one year tests. These trend is most likely due to changes in soil temperature because better biodegradation rates were obtained in the summer and fall months when the soil was warmer than during the winter months. This trend is common and has

**TABLE 3.5**
**RESPIRATION AND FUEL BIODEGRADATION RATES**
**SITE SS-41 (FORMER FUEL PUMPING STATION, BLDG. No. 93)**
**CHARLESTON AFB, SOUTH CAROLINA**

| Location-Depth (feet below ground surface) | Initial (November 1993) [a] | | | 6-Month (January 1995) [d] | | | 1-Year (August 1995) | | |
|---|---|---|---|---|---|---|---|---|---|
| | $K_o$ (% $O_2$/min) | Degradation Rate (mg/kg/year) [b] | Soil [c] Temperature (°C) | $K_o$ (% $O_2$/min) | Degradation Rate (mg/kg/year) | Soil Temperature (°C) | $K_o$ (% $O_2$/min) | Degradation Rate (mg/kg/year) | Soil Temperature (°C) |
| VW1 | 0.0053 | 450 | NS [e] | 0.00055 | 50 | NS | 0.0013 | 130 | NS |
| VW2 | 0.0067 | 630 | NS | 0.00027 | 25 | NS | 0.0014 | 140 | NS |
| MPA-5 | NS | NC [f] | NS | 0.00028 | 31 | 13.5 | 0.00093 | 110 | 25.1 |
| MPA-8 | 0.0070 | 700 | 18.0 | 0.00063 | 70 | 16.4 | 0.0023 | 280 | 23.2 |
| MPB-5 | NS | NC | NS | 0.00079 | 79 | 13.9 | 0.0040 | 360 | 24.9 |
| MPB-8 | 0.0062 | 660 | 18.5 | 0.00065 | 65 | 16.8 | 0.0034 | 310 | 23.1 |
| MPC-5 | NS | NC | NS | 0.00062 | 63 | NS | 0.0033 | 300 | NS |
| MPC-8 | 0.0061 | 660 | NS | 0.00086 | 86 | NS | 0.0020 | 190 | NS |
| MPD-5 | NS | NC | NS | 0.0011 | 110 | NS | 0.0056 | 510 | NS |
| MPD-8 | 0.0072 | 770 | NS | 0.0064 | 650 | NS | 0.0081 | 730 | NS |

[a] Initial respiration data collected in November 1993; however, pilot testing did not begin until blower start-up July 1, 1994.
[b] Milligrams of hydrocarbons per kilogram of soil per year.
[c] Average soil temperature during respiration test.
[d] Assumes moisture content of the soil is average of initial and final moistures.
[e] NS = Not sampled.
[f] NC = Not calculated.

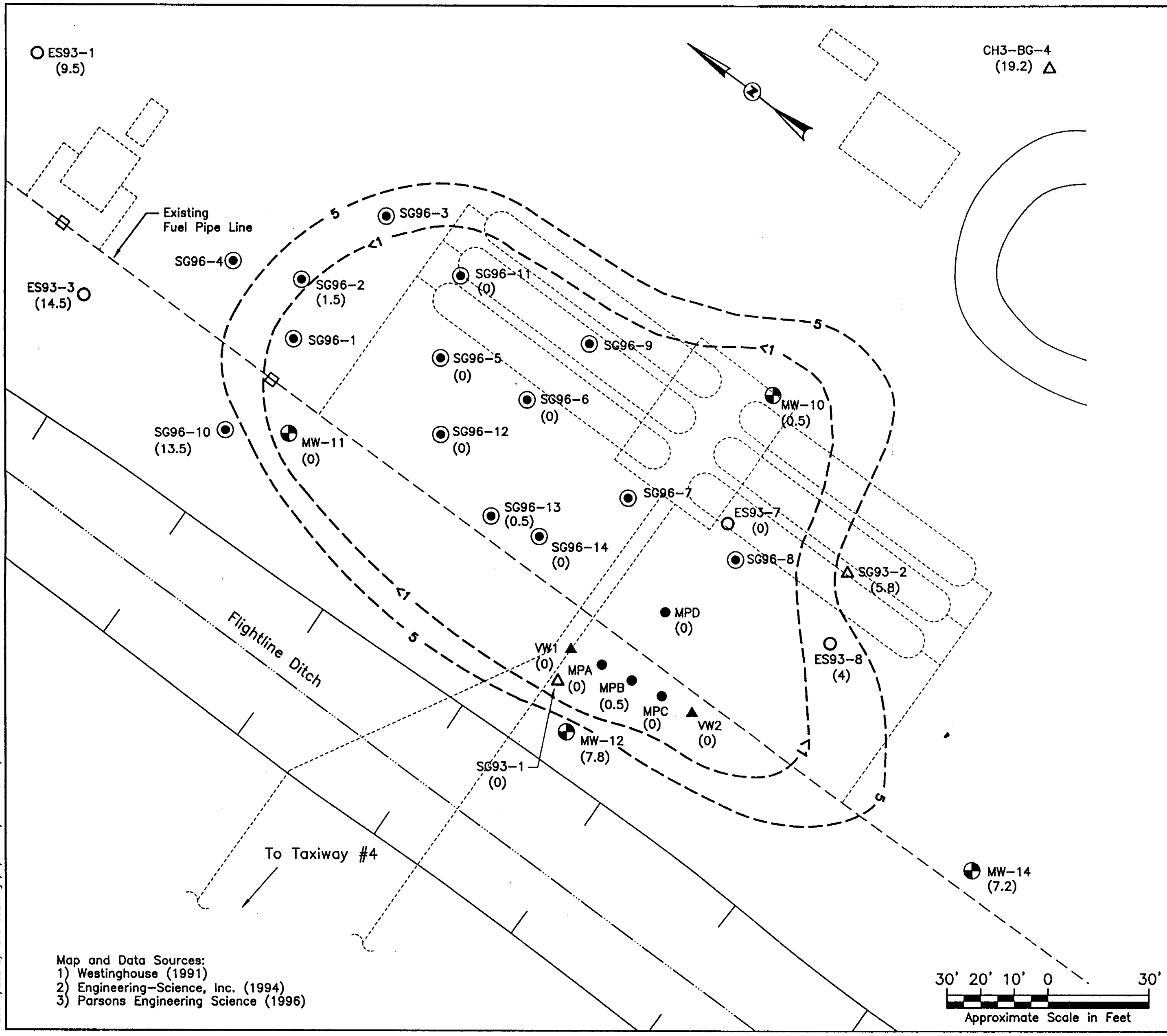
been observed during other bioventing pilot tests on other bases. Both soil temperature and moisture are important factors that can influence fuel biodegradation rates.

Results from the respiration tests indicate that the hydrocarbon-contaminated soils have active microorganism populations and that biological respiration was still occurring in the soils after one year of air injection. Oxygen-depleted soil gas conditions measured in the pilot test area after the blower had been shut down for over one year further supports the conclusion that biorespiration is still occurring in the soils. The biodegradation rates presented in Table 3.5 are based on calculated air-filled porosities (liters of air per kilogram of soil) and a ratio of 3.5 milligrams of oxygen consumed for every 1 milligram of fuel biodegraded. The background soil gas oxygen concentration for Building No. 93 Fuel Pumping Station was 19.2% as measured at a temporary soil gas monitoring point placed in shallow, uncontaminated soils. Therefore, it can be assumed that oxygen uptake observed at this site is primarily the result of microbial biodegradation of fuel hydrocarbons.

## 3.3 EXTENDED SOIL GAS SURVEY

On June 11-13, 1996, Parsons ES conducted an additional soil gas survey at the former Building No. 93 Fuel Pumping Station site. The objectives of the survey were 1) to evaluate the current soil gas conditions in the pilot test area after an extended period of no air injection, 2) to identify areas of the site that still have oxygen-depleted soil gas and hydrocarbon contamination and 3) to assess the need and potential locations for additional bioventing vent wells at the site. Soil gas samples were collected from the two VWs and the VMPs in the pilot test area and from the four existing groundwater monitoring wells (MW-10, MW-11, MW-12, MW-14) located at the site. Each of these points were purged with a small vacuum pump prior to soil gas sampling. Additionally, 14 temporary soil gas probes were installed using a soil gas kit with retractable, screened sampling probes followed by limited purging with a hand vacuum pump. Oxygen, carbon dioxide and TVH concentrations were measured at each sampling point as indicators of current soil gas conditions and potential biorespiration activity. Results of the soil gas survey field data are listed on Figure 3.4 along with a graphical interpretation of soil oxygen distribution around the site. Figure 3.4 also includes results from two prior soil gas surveys conducted at the site in 1993.

The 14 additional temporary soil gas monitoring points (SG96-1 through SG96-14) were installed throughout the site generally at depths of 6 to 7.5 feet bls. As shown in Figure 3.4, oxygen-depleted soil gas was encountered at many of the temporary soil gas points. Soil gas samples could not be retrieved through the probe at points SG96-1, SG96-3 and SG96-4 due to tight soil conditions and smearing of clay on the probe screens. Furthermore, the soil gas readings at points SG96-7, SG96-8 and SG96-9 may represent anomalously-high soil oxygen readings due to potential short circuiting of atmospheric air during sampling. Generally, soil gas readings collected from the existing VWs, VMPs and groundwater monitoring wells are considered the most reliable since their boreholes are sealed air-tight. All but two of these permanent sampling points showed $O_2$ concentrations less than 1% and elevated $CO_2$ concentrations. Monitoring wells MW-12 and MW-14 had deficient soil gas $O_2$




| Soil Gas Sampling Results (1993 and 1996) | | | | |
|---|---|---|---|---|
| Sample Number | Depth/Interval (ft. bls.) | $O_2$(%) | $CO_2$(%) | TVH (ppmv) |
| MW-10 | 6.3-9.6 | 0.5 | 15.0 | 440 |
| MW-11 | 4.3-7.9 | 0 | 13.0 | 12,200 |
| MW-12 | 4.3-12 | 7.8 | 8.0 | 1,600 |
| MW-14 | 4.3-11.2 | 7.2 | 7.8 | 130 |
| MPA | 5 | 0 | 12.5 | 200 |
| MPA | 8 | 0 | 12.0 | 480 |
| MPB | 5 | 0.5 | 14.5 | 200 |
| MPB | 8 | 0.5 | 14.5 | 400 |
| MPC | 5 | 0.2 | 12.0 | 160 |
| MPC | 8 | 0 | 12.0 | 190 |
| MPD | 5 | 0 | 14.5 | 360 |
| MPD | 8 | 0 | 14.0 | 2,000 |
| VW-1 | 5.3-11.6 | 0 | 11.0 | 640 |
| VW-2 | 5.3-11.6 | 0 | 12.0 | 200 |
| SG96-1 | 7 | – | – | – |
| SG96-2 | 5 | 1.5 | 4.3 | 520 |
| SG96-3 | 7 | – | – | – |
| SG96-4 | 6 | – | – | – |
| SG96-5 | 7.5 | 0 | 7.8 | >10,000 |
| SG96-6 | 7.5 | 0 | 14.8 | 1,000 |
| SG96-7* | 7 | 9.5 | 7.2 | 320 |
| SG96-8* | 7.5 | 14 | 6.8 | 110 |
| SG96-9* | 7 | 19.8 | 1.0 | 62 |
| SG96-10 | 6.5 | 13.5 | 4 | 480 |
| SG96-11 | 6 | 0 | 8.5 | 1,000 |
| SG96-12 | 7 | 0 | 12 | >10,000 |
| SG96-13 | 7 | 0.5 | 12 | 2,600 |
| SG96-14 | 7.5 | 0 | 11.5 | 1,400 |
| ES93-1 | 5 | 9.5 | 5.9 | 53 |
| ES93-3 | 4 | 14.5 | 4.0 | 50 |
| ES93-7 | 4 | 0 | 10 | >20,000 |
| ES93-8 | 3.5 | 4 | 4.5 | 1,200 |
| SG93-1 | 3 | 0 | 3.5 | >10,000 |
| SG93-2 | 4.5 | 5.8 | 6.3 | 420 |
| CH3-BG-4 | 4 | 19.2 | 0.5 | – |

LEGEND

- SG96-1 Exploratory soil gas point (1996).
- ES93-1 Exploratory soil gas point (Feb. 1993)
- SG93-1 Exploratory soil gas point (Nov. 1993)
- MPA Permanent multi-depth vapor monitoring point.
- VW1 Bioventing vent well.
- MW-10 Existing groundwater monitoring well.
- <1 Soil oxygen isoconcentration (%).
- (1.5) Soil gas oxygen concentration (%).

NOTES:
1. Bioventing blower was turned off on 6/30/95.
2. The locations of vent wells, monitoring wells, and soil gas points are accurate relative to one another. The locations of these features relative to former structures at the site (i.e buildings, tanks) are estimated.
3. Oxygen levels measured at temporary soil gas points SG96-7, SG96-8, and SG96-9 were anomalous due to short-circuiting. Data from these points were not used in map construction.

Soil Gas Survey Locations
and Results: 1993 – 1996

Site SS-41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

concentrations of 7.8% and 7.2%, respectively. Elevated soil gas TVH concentrations were also detected, particularly in the areas around sampling points MW-11, SG96-5 and SG96-12. Overall, these soil gas results indicate that oxygen-depleted, fuel-contaminated soils exist throughout the site within the areas defined by the former UST pit and fuel filters. The oxygen isoconcentration contours shown in Figure 3.4 illustrate the estimated area of oxygen-depleted soil gas. The map in Figure 3.4 includes historical 1993 soil gas data to further define the areas with oxygen-depleted soil gas. As noted in the figure, the 1996 results from points SG96-7, SG96-8 and SG96-9 are probably anomalous and it is likely that oxygen-depleted soil gas (0% oxygen isocontour) extends to the east as far as well MW-10. Oxygen-depleted and/or oxygen-deficient soil gas conditions also may extend further north than the limits shown in Figure 3.4. Soil samples collected around the former fuel filters during previous site investigations showed hydrocarbon contamination in this area. As discussed in Section 4 of this report, this area will be further investigated during the expanded bioventing field activities.

Previous respiration testing demonstrated that aerobic biodegradation of fuel hydrocarbons can be stimulated under oxygen-enhanced soil gas conditions at this site. It appears that residual soil contamination still exists within the site, especially north and east of monitoring well MW-11. Additional sampling will be required to further define the extent and concentrations of hydrocarbons that are currently present in soil.

## 3.4 POTENTIAL AIR EMISSIONS

Emissions of fugitive vapors from the soil to the atmosphere are not an operating concern for the proposed system. Ambient air was monitored in the breathing zone during the pilot system startup and no hydrocarbons were detected above background concentrations.

During the initial pilot test soil sampling event, Parsons ES determined that soil gas BTEX concentrations were below 18 ppmv. No benzene or toluene were detected by the soil gas laboratory analyses (Table 3.3). Benzene was not detected in soil samples and the total BTEX concentrations in soil was generally low. The average operating air injection flow rate for the pilot-scale bioventing system is low, ranging from approximately 11 to 24 scfm. Monitoring data suggest that the TVH soil gas concentrations decreased over time due to the air injection and biodegradation processes. Minor losses of soil vapors to the atmosphere may have occurred during startup of the pilot test system; however, these potential vapor losses are insignificant and they could not be detected in the breathing zone with field instruments that are accurate to 1 ppmv. Similar conditions should be expected during startup of the expanded system and the low air injection rates, combined with low BTEX concentrations detected in site soils and soil gas, should minimize fugitive emissions that potentially may occur during startup.

## 3.5 RECOMMENDATION FOR FULL-SCALE BIOVENTING

Based on the positive results of the one-year bioventing pilot test, AFCEE has provided funding for the design and installation of an expanded bioventing system that will remediate the remaining fuel-contaminated soils at Building No. 93 Fuel Pumping Station. AFCEE has retained Parsons ES to continue bioventing services at Charleston AFB and to complete the design and installation of an expanded bioventing system. Based on the initial pilot test results, available analytical data, and recently completed soil gas sampling, Parsons ES has prepared a conceptual full-scale bioventing design that will employ one of the existing vent wells (VW2) and a minimum of nine additional VWs to be installed around the site. Up to nine additional VMPs also will be installed to ensure that oxygen is being delivered to contaminated soils. In addition, eight more soil samples will be collected to further define the extent of contamination. Prior to system startup, a baseline groundwater sampling event will be conducted in four of the site monitoring wells. Section 4 provides details on the design, construction, and operation of the expanded system. A design package has been prepared for construction of the system and is included in Appendix A of this Corrective Action Plan.

# SECTION 4

# EXPANDED BIOVENTING SYSTEM

The purpose of the expanded bioventing system is to provide oxygen to stimulate aerobic biodegradation of the remaining hydrocarbon contaminants present in soil at Building No. 93 Fuel Pumping Station. Operation of up to ten VWs is proposed for the expanded system to provide atmospheric air (oxygen) to oxygen-depleted, contaminated soils at the site. This proposed VW network includes one of the existing bioventing wells (VW2) and up to nine additional air injection VWs. Additionally, as many as nine soil borings will be installed and converted to VMPs to determine the full extent of soil contamination at the site. If significant soil contamination is observed in all nine boreholes, additional VMPs may be installed and one or more additional VWs may be installed to treat the larger area of soil contamination. Previous site investigations suggest that the majority of residual subsurface soil contaminants are found in the former UST pit and around the former fuel filters north of the former USTs.

Two regenerative blowers will be used to provide air to the VW network. The existing blower operated almost continuously for one year and its remaining service life is questionable. As a result, two new air injection blowers, two blower enclosures and new electrical wiring will be installed at the site. The existing pilot test blower, blower enclosure and piping will be dismantled and removed from the site. There are underground utilities at or near the site, including the primary fuel hydrant fuel line, subsurface electrical lines and water lines. An electrical transformer (surface mounted) was installed by the base in 1994 to restore primary power to the site in order to power the pilot test blower. Currently, subsurface electrical lines connect the transformer to an electrical disconnect switch and circuit breaker on a pole beside the blower. System design details are provided in Appendix A.

## 4.1 OBJECTIVES

Following its installation, the primary objectives for operating the expanded bioventing system will be to:

- Optimize the system to fully aerate unsaturated, subsurface soils in areas of the site designated for bioventing remediation;
- Reduce the existing hydrocarbon contaminant concentrations to below Tier 1 RBCA risk-based cleanup levels or other cleanup criteria established for the site. In the absence of established regulatory cleanup goals for specific contaminants (i.e. COCs), such as TRPH, reduce the concentrations to levels that will gain regulatory approval for no further action;
- Eliminate the potential for continued hydrocarbon partitioning to groundwater, particularly the BTEX compounds, by removing the contaminant source from vadose zone soils; and

- Provide the most cost-effective soil remediation alternative for the site.

As stated earlier in this report, soil TRPH concentrations will be further assessed during the bioventing remediation activities, even though there are no established TRPH soil cleanup criteria for this site. There are, however, South Carolina risk-based screening levels (RBSLs) and site-specific target levels (SSTLs) established for several PAHs, individual BTEX compounds and other VOCs, which also will be further investigated in the soils. Benzene exceeded two tiers of RBCA screening in groundwater at this site and several PAHs failed the Tier 1 screening criteria for soils. Reduction of organic compounds in the soils using the bioventing technology is expected to benefit groundwater remediation by removing the primary contaminant source.

## 4.2 BASIS OF DESIGN

Site investigation data, pilot test data, and experience at similar bioventing sites provide the basis of this bioventing design. The expanded bioventing system was designed to provide oxygen to areas having significant soil contamination. Shallow vadose zone soils and deeper soils in the hydrocarbon smear zone have been targeted for remediation. The extent and magnitude of soil contamination will be better defined around the Building No. 93 Fuel Pumping Station as part of this project. Therefore, the design includes installation of nine or more additional soil borings and collection of eight additional soil samples to further investigate soil contamination. If significant vadose zone contamination is not encountered in a soil boring, either a VMP will be installed or the boring will be abandoned. A minimum of nine additional VMPs are proposed for this site.

The expanded soil investigation will include the area around the former fuel filters and valve pit on the north end of the site where soil contamination was reported during prior site assessments (Figure 2.3). One or more exploratory soil borings will be advanced to the water table in this area. If significant vadose zone contamination is encountered during field screening of soils, then one or more VWs and additional VMPs will be installed to remediate this area. The current design proposes one VW and two VMPs to be installed near the former fuel filters based on suspected soil contamination in this area. This proposed VW and the VMPs will be installed if significant soil contamination is confirmed in this area, or they will be eliminated if no soil contamination is found. If the soil contamination is extensive in this area, another VW will be installed as needed to remediate the entire area around the former fuel filters (total of 10 new VWs). It is anticipated that only one VW will be required to remediate soils around the fuel filters due to their limited size as a hydrocarbon source area.

Pilot test data such as operating pressures, air injection flow rates and radius of oxygen influence were considered during design development. These data were considered in the placement of the VWs and sizing of a full-scale blower system. In addition to the pilot test data from this site, experience at other sites with similar site conditions and soils was considered in design development. The significant design parameters and considerations are as follows:

- A VW radius of oxygen influence of 35 feet was used, with overlapping zones of oxygen influence between each well. This places the well spacings on centers of approximately 60 to 65 feet , which will cover the area of confirmed vadose zone soil contamination.
- Two bioventing blowers will be used. The VWs will be piped to two manifolds configured so that each blower will supply air to five VWs. This will allow better control of flow rates to individual wells and facilitate system optimization.
- An air injection pressure capability up to 65 inches of water was assumed in sizing the full-scale bioventing blowers, with long-term operating pressures in the range of 30 to 40 inches of water pressure during dry soil conditions. This is consistent with varying pressures observed during the extended pilot test when the water table is both elevated and low at the site.
- A total system air injection flow rate of between 60 to 100 scfm was assumed based on experience at this and other sites. Each VW will receive approximately 6 to 10 scfm of air (approximately 30 to 50 scfm delivered by each blower).

The full-scale design will utilize two new regenerative blowers in pre-fabricated enclosures to provide air to the existing and proposed VWs. The proposed locations of the nine additional VMPs were based on the following design criteria:

- to provide additional information on the extent of subsurface soil hydrocarbon contamination,
- to evaluate the magnitude of contaminant reduction through soil gas sampling, and
- to provide important oxygen influence data.

The proposed VMPs will be located within the anticipated radius of influence for the combined VW system to monitor system effectiveness throughout the project duration.

## 4.3 SYSTEM DESIGN

The expanded bioventing system at Building No. 93 Fuel Pumping Station will incorporate two new regenerative blowers, two blower enclosures and nine proposed VWs. Also, up to nine new VMPs will be constructed to monitor soil gas conditions and to ensure adequate oxygen influence throughout the area of soil contamination. The new VWs will be constructed with 2-inch diameter PVC screens and casings set in 8.5-inch nominal diameter boreholes. The screened interval of each VW will consist of 10 feet of 0.020-inch slot recovery well screen installed from approximately 5 to 15 feet bls. This screened interval will position 3 to 6 feet of the screen below the water table depending on the well's location and the fluctuating water table elevations. Based on the depth to groundwater, the screened intervals may have to be adjusted slightly for each well installation to ensure that an adequate length of screen is positioned above the water table for air injection. Figure 4.1 shows the locations of the existing and proposed new VWs and VMPs. Well and piping configuration and other design details are included in the design package provided in Appendix A.

The VWs will be manifolded using 1.5-inch diameter high density polyethylene (HDPE) piping as the conduit for the injected air to flow from the blowers to the VWs. Each blower will operate a series of five bioventing wells and each VW will have an individual piping run from the wellhead to the designated blower enclosure. Piping will be buried at a minimum depth of 12 inches beneath the ground surface. The piping runs from five VWs will be connected to a common manifold inside each enclosure, which in turn will be connected to a new 2 HP regenerative blower. A separate (manual) flow control valve and flow measurement port will be installed on each pipe run at the manifold to allow adjustment of the air flow to each VW. The blowers and valving assemblies will be housed in individual, weatherproof enclosures for protection from the elements and for security purposes.

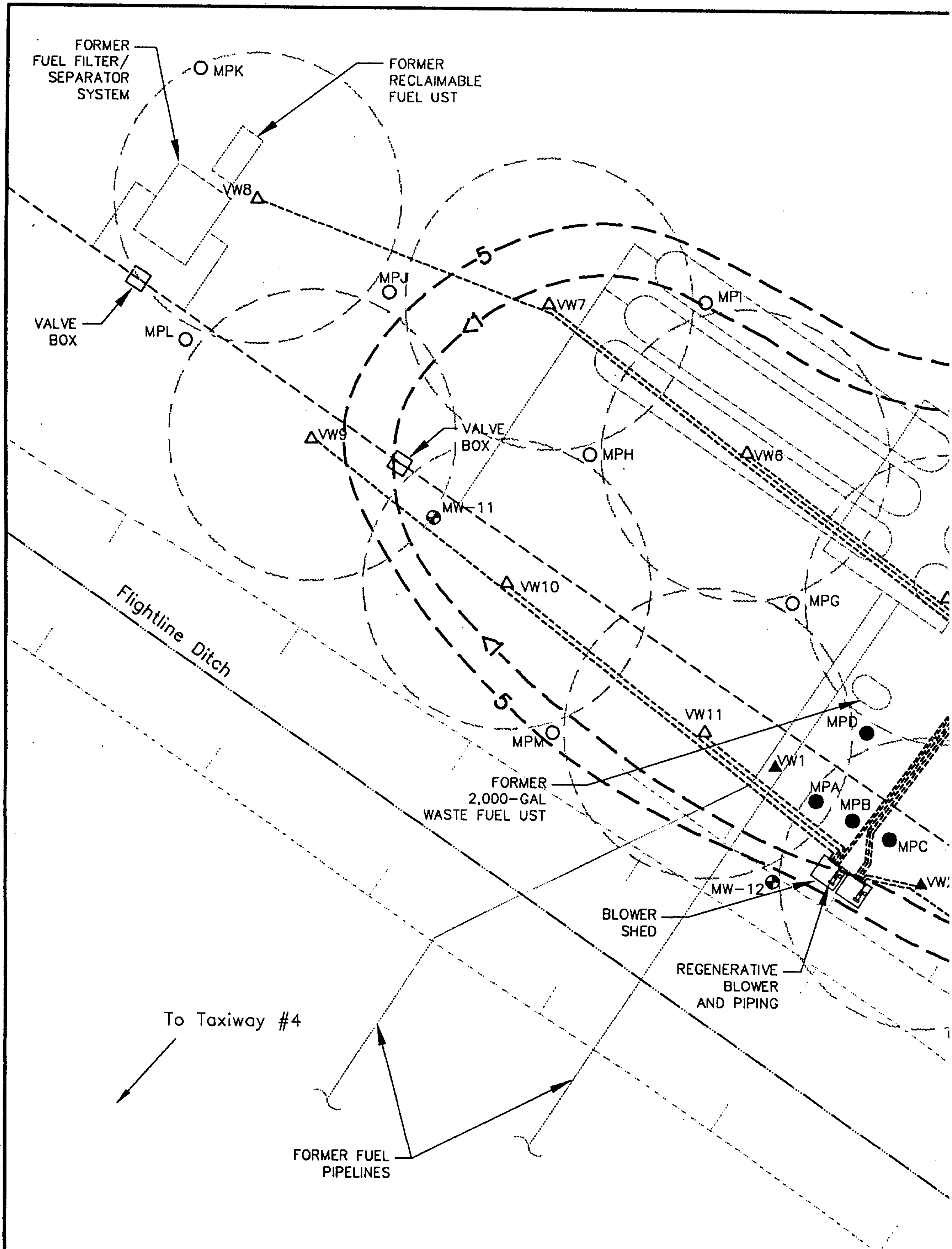
Based on pilot test results and the proposed well spacing design, a maximum air injection rate of 6 to 10 scfm at each VW should be sufficient to supply oxygen to the remaining contaminated soils and sustain *in situ* fuel biodegradation. The effective radius of oxygen influence around the existing VWs exceeded 30 feet using an air injection rate of between 1.5 to 2 scfm per foot of vent well screen. Similar air flow capabilities are expected for the proposed new VWs, although they will likely be operated at lower air flow rates ranging from 1 to 1.5 scfm per foot of well screen.

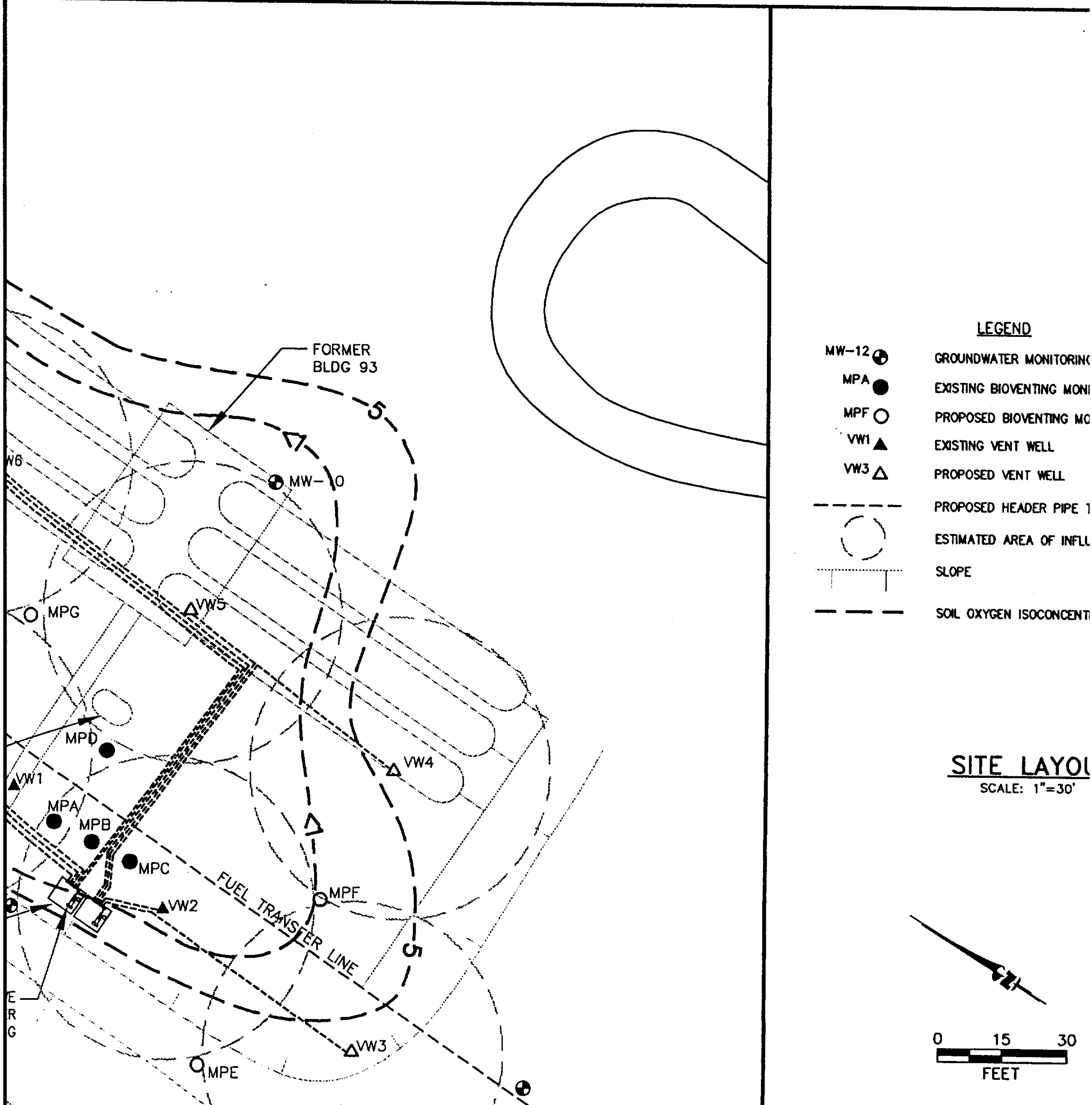
The proposed VW locations were selected to provide coverage of contaminated, oxygen-depleted soils identified during the soil gas survey and during previous site investigations. Existing 4-inch pilot test well VW2 will continue operating as part of the full-scale system at an air injection rate of 8 scfm or less. Existing vent well VW1 will not be incorporated into the full-scale system at this time because it showed poor air flow performance and it is located too close to well VW2 (radius = 40 feet) to maintain the minimum 60-feet on center design spacing. Vent well VW1 will be converted to a VMP, with the capability to be incorporated into the system for air injection if this is needed in the future.

Up to nine additional soil borings will be advanced to further define the extent of soil contamination at this site. Figure 4.1 shows the proposed locations of these borings, which will be converted to VMPs. If field screening during installation of the soil borings shows significant vadose zone contamination north of the area currently proposed for bioventing treatment, then one additional VW and additional VMPs will be installed in this area.

### 4.4 PROJECT SCHEDULE

The following schedule for the bioventing system upgrade is contingent upon approval of the Work Permit Request.

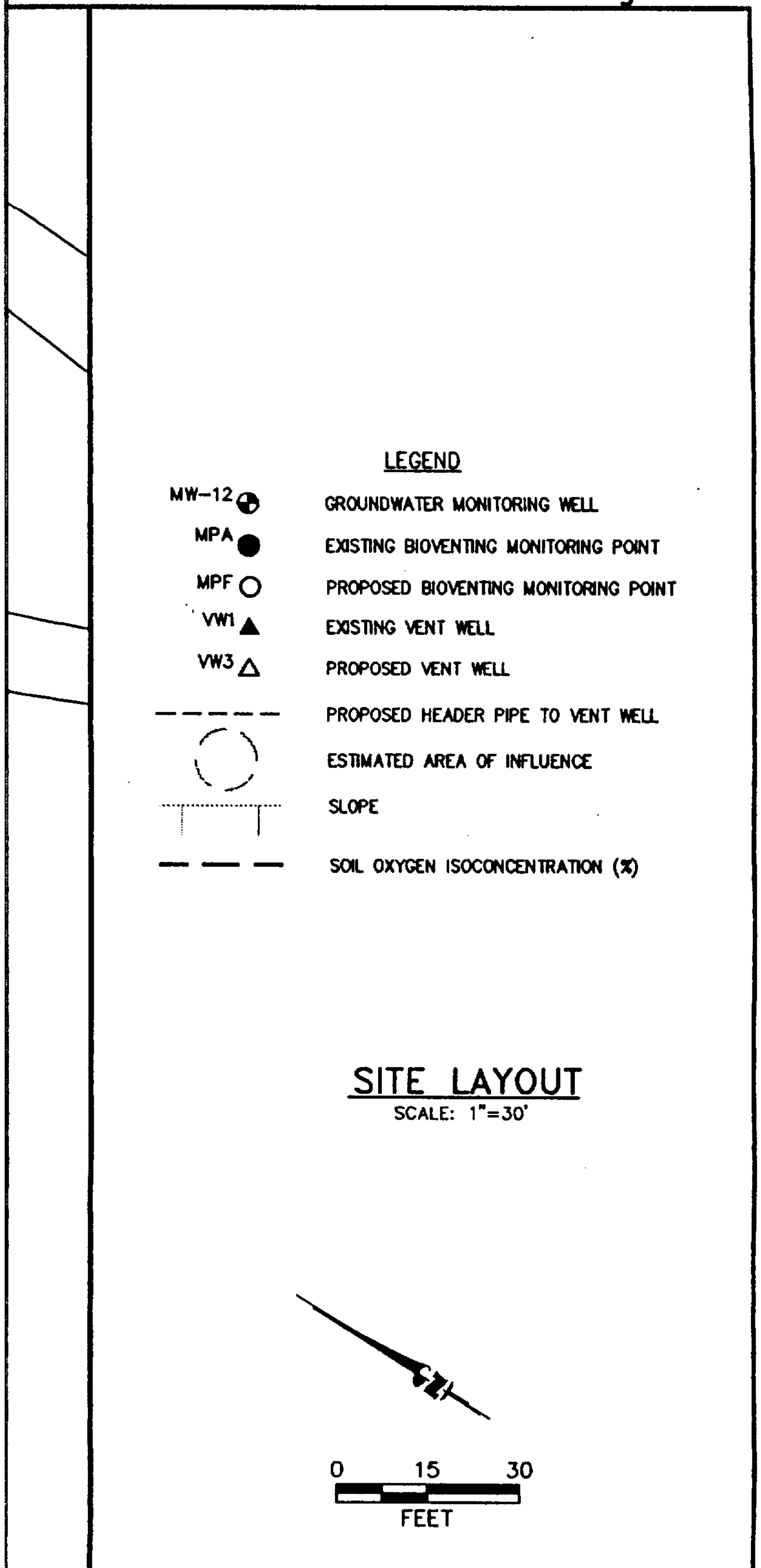

FORMER
FUEL FILTER/
SEPARATOR
SYSTEM
MPK
FORMER
RECLAIMABLE
FUEL UST
VW8
5
MPJ
MPI
VW7
VALVE
BOX
MPL
4
VALVE
BOX
VW9
MPH
VW6
MW-11
VW10
MPG
Flightline Ditch
4
5
VW11
MPD
MPM
VW1
FORMER
2,000-GAL
WASTE FUEL UST
MPA
MPB
MPC
MW-12
BLOWER
SHED
REGENERATIVE
BLOWER
AND PIPING
To Taxiway #4
FORMER FUEL
PIPELINES




Site Layout – For
Bldg. 93 Fuel Pumping

Site SS-41
Bldg. 93 Fuel Pumping
Charleston AFB, South

Figure 4.1




Site Layout – Former
Bldg. 93 Fuel Pumping Station

Site SS–41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina

| Event | Start Date | End Date | Duration (working days) |
|---|---|---|---|
| Submit Draft Corrective Action Plan and Design Package to AFCEE/ERT and Charleston AFB | NA | 1 August 1996 | NA |
| Charleston AFB Review Period | 2 August 1996 | 27 Sept. 1996 | 40 days |
| Respond to Comments on Draft CAP | 30 Sept. 1996 | 8 Nov. 1996 | 30 days |
| Submit Draft Final CAP to AFCEE/ERT, Charleston AFB, and SCDHEC [a/] | NA | 12 Nov. 1996 | NA |
| Draft Final Review Period | 13 Nov. 1996 | 12 Feb. 1997 | 60 days |
| Respond to comments on Draft Final CAP | 13 Feb. 1997 | 19 March 1997 | 24 days |
| Final CAP and Design Package to AFCEE/ERT, Charleston AFB, and SCDHEC | NA | 30 April 1997 | NA |
| Submit Work Permit (digging permit) Request | NA | 10 Feb. 1997 | NA |
| Construction of Expanded System/System Startup (Three Mobilization Phases) | 24 Feb. 1997 | 23 May 1997 | 65 days |
| Complete Construction Drawings/O&M Manual/Final CAP Revisions | 26 May 1997 | 7 July 1997 | 30 days |

[a/] Draft Final copies for SCDHEC submitted by Charleston AFB.

## 4.5 SYSTEM OPERATION, MAINTENANCE, AND MONITORING

Following system installation, Parsons ES engineers will perform system startup and optimization. An O&M plan and as-built system drawings will be prepared and submitted to AFCEE and Charleston AFB. After the system has been optimized it will operate continuously until performance monitoring indicates that remedial objectives have been reached. The average of the biodegradation rates observed during one year of respiration testing (average of all three respiration testing events) was 315 milligrams TPH per kilogram of soil per year, although biodegradation rates were generally much greater in the summer months compared to the winter months (Table 3.5). The highest TRPH value detected in the bioventing test area was 1,400 mg/kg at MPB (7.5-foot depth). Confirmation soil sampling after one year of bioventing showed up to two orders of magnitude TRPH reduction and the complete reduction of all soil BTEX compounds to below detection limits (Table 3.3). Therefore, it is reasonable to assume that the expanded bioventing system has the capability to biodegrade the remaining

BTEX compounds in unsaturated soils to below detection limits in a period of one to two years. This assumes that the bioventing is able to affect the targeted soils throughout the entire treatment period. Fluctuations in groundwater elevations may limit oxygen transport to contaminated soils at certain times of the year. Since there are no established regulatory cleanup levels for TRPH in soil, only a qualitative reduction of soil TRPH will be evaluated for this site to support a "no further action" site closure.

### 4.5.1 System Operation

At startup of the full-scale system, it will be necessary to optimize the air injection rates and to ensure proper operation of the blower systems. Flow rate optimization is accomplished by gradually increasing the flow rate to each VW until soil gas oxygen concentrations at all VMPs reach a minimum concentration of approximately 5 percent. Oxygen levels in excess of 5 percent at the outer VMPs may indicate that the volume of air passing through the soil exceeds the biological oxygen utilization demand. The blower systems will be adjusted to ensure that they are producing the required flow rates and pressures for air injection.

Following flow rate optimization, the system will run continuously and will require minimal maintenance as described below. Parsons ES has been contracted by AFCEE to provide one year of system operations and maintenance (O&M) support under Option 1 of the Extended Bioventing Program. O&M support will include performing system repairs should the bioventing system fail to operate properly.

### 4.5.2 System Maintenance

System maintenance requirements for the proposed bioventing system are minimal because the regenerative blowers are virtually maintenance-free. The only recurring maintenance required is a monthly check of the air filters, which will routinely be conducted by Charleston AFB. The filters are generally replaced when the vacuum across the inlet filter reaches a reading that is 10 to 15 inches of water greater than the reading with a clean filter. The time period between filter changes is dependent on site conditions, and is typically every three to six months. The O&M manual will further detail maintenance requirements. Parsons ES is responsible for one year of maintenance support under Option 1 of the Extended Bioventing Project. Should the blower system give indications of an electrical or mechanical problem, such as a significant change in outlet pressure, abnormal noises from a blower, or system failure during the first year of operation, Parsons ES will be responsible for repairing the system. Prior to mobilizing to the site, Parsons ES may request that a base electrician verify that adequate power is still being supplied to the blower motors. Once adequate power to the motors has been verified, Parsons ES will take the necessary actions to repair the blower system. Following the first year of O&M support by Parsons ES, Charleston AFB will be responsible for continued system maintenance.

### 4.5.3 System Performance Monitoring

Routine monitoring of the bioventing system will include system checks of blower operations, including outlet pressures, inlet vacuums, and exhaust temperatures every two weeks. These routine system checks will be performed by Charleston AFB personnel during and after the first year of operation.

To provide baseline data against which the progress of remediation can be evaluated, additional soil, soil gas and groundwater samples will be collected during installation of the full-scale bioventing system. These data and the data collected during the pilot test project, the previous RFI studies, and the June 1996 soil gas survey will be used as a basis for evaluating the effectiveness of the full-scale bioventing system.

Soil samples will be collected from all boreholes advanced during installation of the VMPs. Samples will be collected at approximate 2-foot intervals and they will be screened in the field for organic vapors using a PID. Using the PID screening results as a guide to determine relative contamination, eight soil samples will be sent to a South Carolina-certified analytical laboratory for analysis of BTEX by Method SW8020 and PAHs by Method SW8310 (modified). Additionally, five of these samples will be laboratory-analyzed for TRPH by Method SW8015 (modified) and three of the samples will be analyzed for metals by Inductively Coupled Plasma (ICP) using Method SW3050/SW6010. These soil samples will be collected from different boreholes for laboratory analyses if field screening indicates significant contamination is present at these locations.

Soil gas screening will be conducted with field instruments at all VMPs and VWs prior to system startup to establish baseline $O_2$, $CO_2$ and TVH levels. In addition, soil gas samples will be collected from eight VMPs and will be forwarded to Air Toxics Ltd. of Folsom, California for analysis of TVH and BTEX by Method TO-3. The locations of these soil gas samples will be determined based on the field screening results. The eight VMPs exhibiting the highest soil gas TVH concentrations (measured with field instruments) will be sampled for laboratory analysis. Existing VMPs that had soil gas samples collected and laboratory-analyzed during the pilot test will not be resampled for laboratory soil gas analyses.

In response to SCDHEC comments to the Draft Final CAP (Appendix B) baseline groundwater sampling will be conducted prior to system startup. Four site monitoring wells and one VW will be sampled and analyzed for VOCs by Method SW-8260 and for SVOCs by Method SW-8270.

System performance monitoring by Parsons ES under Option 1 of the Extended Bioventing Project will include *in situ* respiration testing during a site visit after one year of full-scale system operation. Soil gas samples will also be collected from the same eight VMPs sampled during full-scale system installation and reanalyzed for BTEX and TVH using Method TO-3. Another round of groundwater sampling will be conducted in the four site monitoring wells at that time. No final confirmation soil sampling will be performed under Option 1 of the Extended Bioventing Project.

Prior to performing the 1-year respiration tests and soil gas sampling, the blowers will be turned off for 30 days to allow soil gas to equilibrate so that 1-year data can be compared to initial soil gas data. Air will be injected into VWs and VMPs for approximately 20 hours, and then shut off. Oxygen uptake will be monitored in the VMPs for approximately 72 hours to measure the rate at which oxygen decreases in the soil gas. These data will then be used to estimate the current biodegradation rates and to evaluate the progress of contaminant removal and system effectiveness. As the fuel in the soil is depleted, the respiration activity of the indigenous microorganisms is reduced, and slower oxygen utilization rates will result. The use of oxygen utilization rates and soil gas chemistry as indicators of remaining contaminant concentration decreases the likelihood of premature closure soil sampling events.

System monitoring and *in situ* respiration test data will be analyzed to determine the progress of soil remediation. Estimates of contaminant reduction and time remaining to complete soil remediation will be based on the data collected during the respiration tests (oxygen utilization rates), quantitative estimates of the long-term biodegradation rates, and decreases in soil gas concentrations. If soil gas data indicate that the soils have been sufficiently remediated, closure soil sampling will be recommended to the base.

Charleston AFB will be responsible for monitoring the bioventing system after the initial year of full-scale system operation when Parsons ES's obligations will be complete. It is recommended that annual respiration testing and soil gas sampling be performed to evaluate the progress of remediation. Assuming that these monitoring activities are performed by a contractor, the annual cost to perform these activities is estimated as $17,000. In addition to these activities, monitoring the system pressure, vacuum, and temperature should be performed every two weeks.

# SECTION 5

# HANDLING OF INVESTIGATION-DERIVED WASTES

Soil generated during drilling of the VWs and VMPs will be containerized in 55-gallon drums and transported to a staging area designated by Charleston AFB. Each drum will be clearly labeled as to its contents, site name, location, and date of generation. The volume of waste soil generated by these processes is expected to be approximately one 55-gallon drum per VW borehole and one-half of a drum capacity per VMP borehole.

Waste disposal will be coordinated with the base according to base waste-handling procedures. It is anticipated that results of the laboratory analyses from the eight environmental soil samples will adequately represent contaminant concentrations in the waste soils contained in all the drums for waste disposal purposes. Additionally, previous analytical data generated during the RFI can be used to further characterize soil contaminants that are expected to be present in wastes generated at this site. Additional waste characterization of drum composite samples will be performed if SCDHEC determines that the results of environmental samples are not acceptable to characterize the waste soils for disposal. Based on past work at this site, soils with little to no contamination (below certain regulatory BTEX and TPH target concentrations) can be spread out on site at their point of origin with SCDHEC approval. Soils that exceed the BTEX and TPH land application criteria must be disposed of by incineration or by other regulatory-approved methods.

Decontamination of the auger stems, split spoon samplers and other downhole tools will be performed using hot pressurized water at a temporary decontamination area set up at the site. Decontamination water will be placed in 55-gallon drums and then transported to a base-approved staging area. As with the waste soils, analyses of a composite sample will be performed if required by SCDHEC for off-base disposal of the liquids. The volume of liquid wastes from decontamination is expected to be less than 100 gallons.

# SECTION 6

# BASE SUPPORT REQUIREMENTS

The following support from Charleston AFB is needed prior to arrival of the Parsons ES team and subcontractor(s) at the base:

- Assistance in obtaining a base digging permit.
- Obtaining all necessary regulatory permits and approvals for installation of the VWs, VMPs, and to conduct soil borings and sampling.
- Assistance in obtaining an extension to, or reissuance of, the Underground Air Injection Control Permit from SCDHEC to allow construction and operation of the proposed new VWs and continued operation of existing well VW2. This permit should also cover the planned short-term air injection into the VMPs during respiration tests.
- Provide arrangements for gate passes, vehicle passes, and flightline driver training for several subcontractor personnel and up to two Parsons ES employees. Flightline vehicle placards will be needed for two Parsons ES trucks and several subcontractor support trucks and the drill rig. These passes must be valid for the expected duration of VW installation (about 1 week) and the full-scale system installation and startup (about 3 weeks).
- A municipal water supply for well construction and decontamination activities.

During full-scale bioventing, base personnel will be required to check the blower systems once every two weeks to ensure that they are operating properly, record air injection pressures and temperatures, and replace air filters as needed. Parsons ES will provide a maintenance procedures manual and a brief training session.

1. If a blower stops working, notify Mr. Grant Watkins of Parsons ES-Cary at (919) 677-0080, Mr. John Ratz of Parsons ES - Denver at (303) 831-8100, or Capt. Ed Marchand of AFCEE at (210) 536-4364.
2. Arrange site access and security passes for a Parsons ES technician to conduct respiration testing and soil gas sampling approximately one year after full-scale system installation and start up.

# SECTION 7

# POINTS OF CONTACT

Mr. Al Urrutia
437 CES/CEVR
100 W. Stewart Avenue
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(803) 566-2697

Mr. Marty Faile
AFCEE/ERT
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Brooks AFB, TX 78235-5363
(210) 536-4342
Fax: (210) 536-4330

Major Ed Marchand
AFCEE/ERT
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Brooks AFB, TX 78235-5363
(210) 536-4364
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Mr. John Ratz, Project Manager
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(303) 831-8100
Fax: (303) 831-8208

Mr. Grant Watkins, Site Manager
Parsons Engineering Science, Inc.
401 Harrison Oaks Blvd., Suite 210
Cary, NC 27513
(919) 677-0080
Fax: (919) 677-0118

# SECTION 8

# REFERENCES


Engineering-Science, Inc. 1994. *Part I, Bioventing Pilot Test Work Plan and Part II, Draft Interim Bioventing Pilot Test Results Report for IRP Site SS-41, Former Flightline Fuel Pump House, Charleston AFB, South Carolina.* January.

Charleston AFB. 1993. Personal communication; receipt of preliminary laboratory reports and site maps for former fuel pump station #3 from 437 CES/CEVR.

Halliburton NUS. 1993. *Installation Restoration Program RCRA Facility Investigation Work Plan for Charleston AFB, South Carolina.* July.

Halliburton NUS. 1995. *Draft RCRA Facility Investigation Report for Charleston AFB, South Carolina.* June.

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing.* January.

Parsons Engineering Science, Inc. 1996. *Draft Site Assessment/Corrective Action Plan, Fuel Hydrant System (Site SS-41), Charleston Air Force Base, South Carolina.* May.

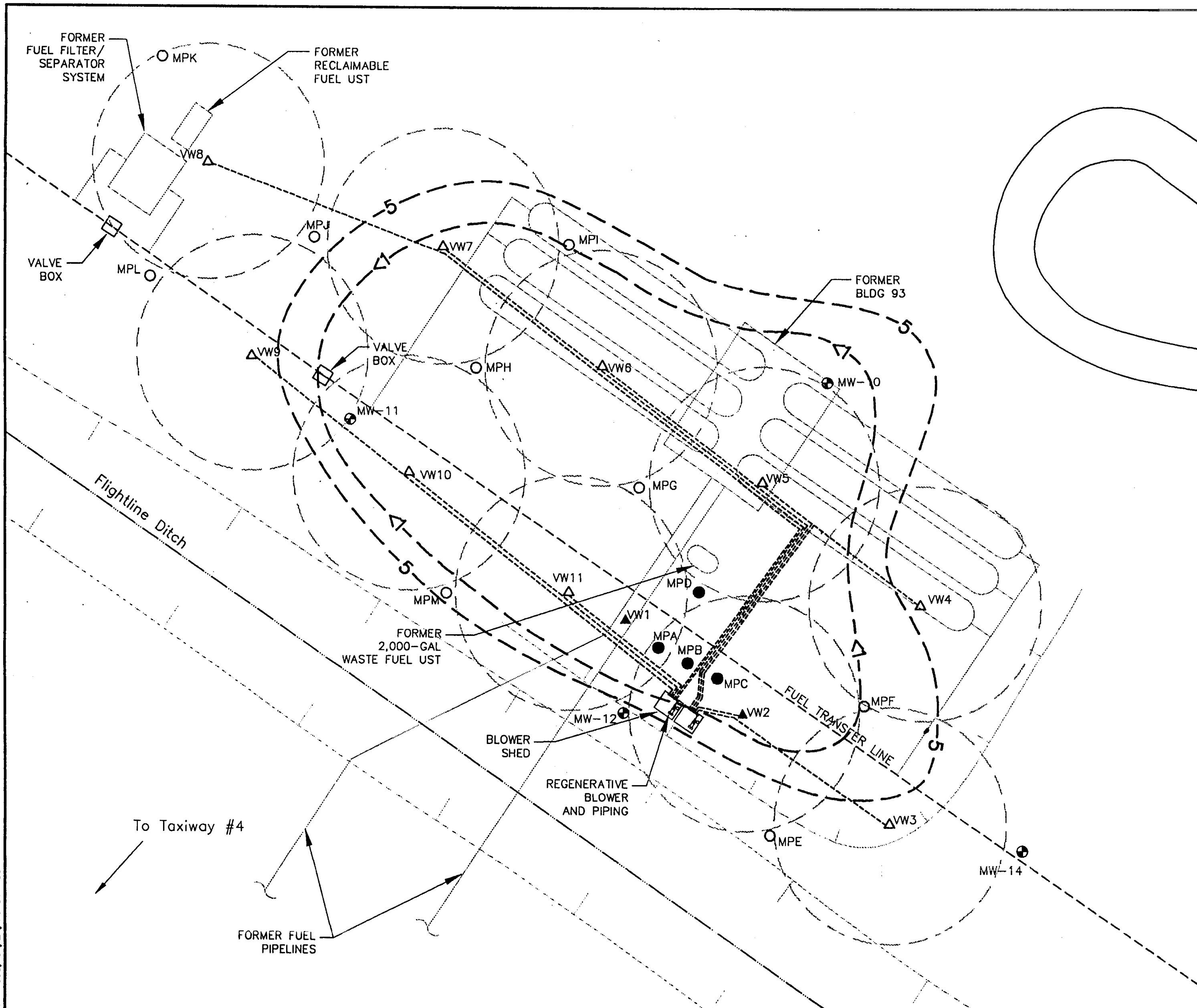
SCDHEC, 1995. *Risk-Based Corrective Action for Petroleum Releases.* South Carolina Department of Health and Environmental Control. June, 1995.

USEPA. 1995. Region IX Preliminary Remediation Goals (PRGs). Second Half 1995. September 1, 1995.

Westinghouse, Inc. 1991. *Report of Geotechnical Engineering and Environmental Services, ADAL Apron/Hydrant Fuel System, Charleston Air Force Base.* Prepared for CRSS Architects, Inc. November.

# APPENDIX A
# DESIGN PACKAGE

Figure 4.1




LEGEND

| | |
|---|---|
| MW-12 | GROUNDWATER MONITORING WELL |
| MPA | EXISTING BIOVENTING MONITORING POINT |
| MPF | PROPOSED BIOVENTING MONITORING POINT |
| VW1 | EXISTING VENT WELL |
| VW3 | PROPOSED VENT WELL |
| | PROPOSED HEADER PIPE TO VENT WELL |
| | ESTIMATED AREA OF INFLUENCE |
| | SLOPE |
| | SOIL OXYGEN ISOCONCENTRATION (%) |

SITE LAYOUT

SCALE: 1"=30'

0 15 30 FEET

Site Layout – Former Bldg. 93 Fuel Pumping Station

Site SS-41
Bldg. 93 Fuel Pumping Station
Charleston AFB, South Carolina



PARSONS ENGINEERING SCIENCE, INC.

CONSTRUCTION DRAWINGS FOR

# EXPANDED BIOVENTING SYSTEM
# SITE SS-41
# CHARLESTON AIR FORCE BASE

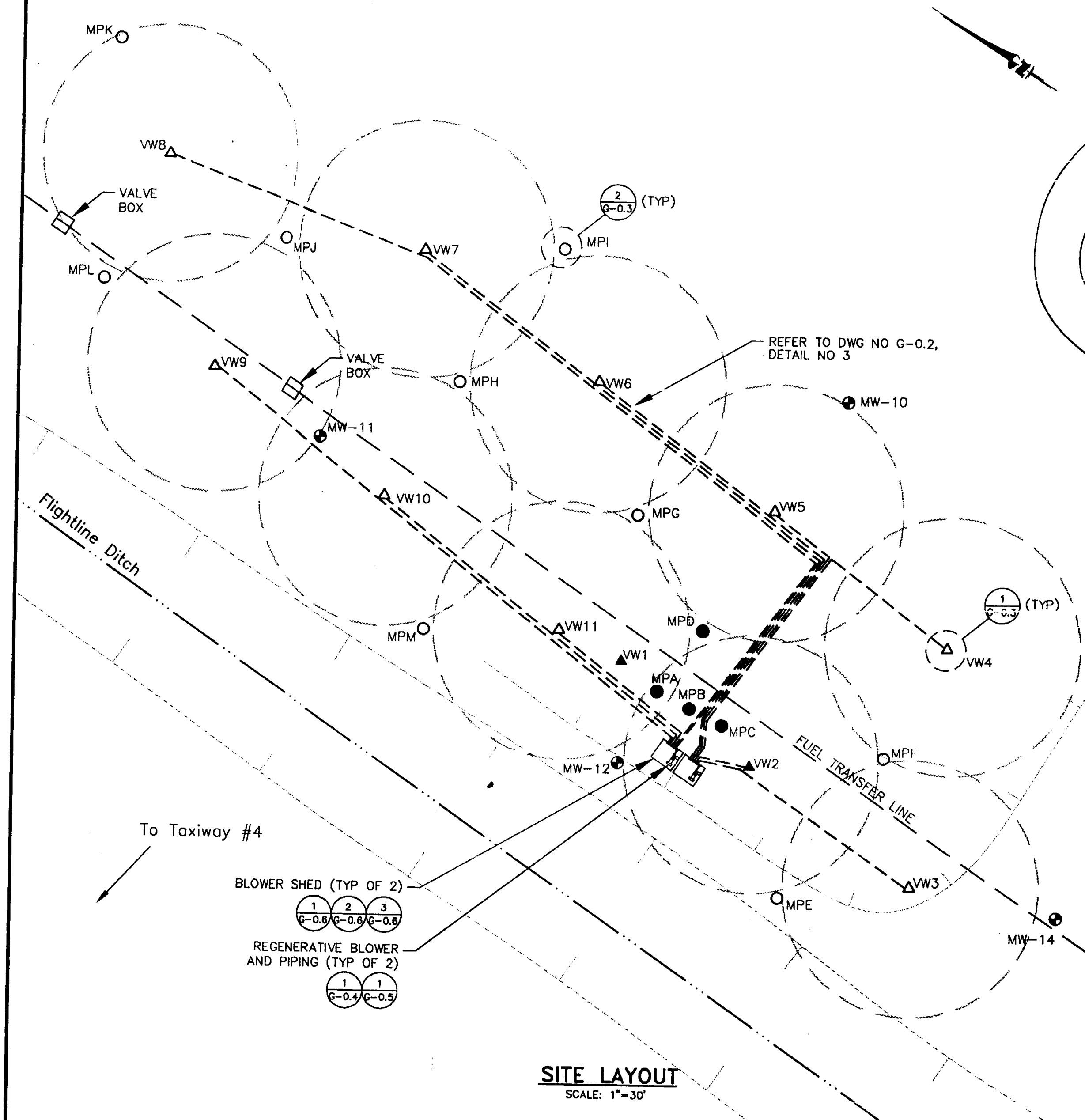
PREPARED FOR

## AFCEE

JULY 1996

## DRAWING INDEX

| DRAWING NO | |
|---|---|
| G-0.1 | TITLE SHEET AND SITE LAYOUT |
| G-0.2 | LEGEND AND STANDARD TRENCH DETAILS |
| G-0.3 | VENT WELL AND MONITORING POINT STANDARD DETAILS |
| G-0.4 | BLOWER P & ID |
| G-0.5 | BLOWER PIPING LAYOUT DETAIL |
| G-0.6 | BLOWER SHED FIELD INSTALLATION DETAIL AND BLOWER SHED CONSTRUCTION DETAILS |




SITE LAYOUT
SCALE: 1"=30'

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|---|---|
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| Drawn JH | |
| Checked | 7/24/96 |
| Reviewed | 7/24/96 |
| Approved | 7/25/96 |
| Rev No A | 7/19/96 65% DESIGN |

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

EXPANDED BIOVENTING SYSTEM
SITE SS-41
CHARLESTON AIR FORCE BASE

TITLE SHEET AND SITE LAYOUT

DRAWING NO G-0.1 REV A

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## ABBREVIATIONS

| | |
|---|---|
| AIJ | AIR INJECTION |
| APPROX | APPROXIMATE |
| ASTM | AMERICAN SOCIETY OF TESTING AND MATERIALS |
| & | AND |
| @ | AT |
| CBM | CENTER BACK MOUNT |
| CLR | CLEAR |
| DIA | DIAMETER |
| EB | EXPLORATORY BORING |
| ECC | ECCENTRIC |
| EW | EACH WAY |
| FOT | FLAT ON TOP |
| FPT | FEMALE PIPE THREAD |
| FT | FOOT |
| GALV | GALVANIZED STEEL |
| HDPE | HIGH DENSITY POLYETHYLENE |
| ie | FOR EXAMPLE |
| LM | LOWER MOUNT |
| MAX | MAXIMUM |
| MIN | MINIMUM |
| MP | MONITORING POINT |
| MPT | MALE PIPE THREAD |
| NO, # | NUMBER |
| NPT | NATIONAL PIPE THREAD |
| NTS | NOT TO SCALE |
| OC | ON CENTER |
| OD | OUTSIDE DIAMETER |
| PVC | POLYVINYL CHLORIDE |
| PW | PROPOSED WELL |
| RED | REDUCER |
| REF | REFERENCE |
| SCH | SCHEDULE |
| S | SOCKET |
| SPVC | SLOTTED POLYVINYL CHLORIDE |
| ST STL | STAINLESS STEEL |
| TYP | TYPICAL |
| UST | UNDERGROUND STORAGE TANK |
| VW | VENT WELL |
| W/ | WITH |
| WN | WELD NECK |
| WWF | WELDED WIRE FABRIC |

## SYMBOLS

| | |
|---|---|
| MW-12 ◒ | GROUNDWATER MONITORING WELL |
| MPA ● | EXISTING BIOVENTING MONITORING POINT |
| MPF ○ | PROPOSED BIOVENTING MONITORING POINT |
| VW1 ▲ | EXISTING VENT WELL |
| VW3 △ | PROPOSED VENT WELL |
| – – – – – | PROPOSED HEADER PIPE TO VENT WELL |
| | ESTIMATED AREA OF INFLUENCE |
| | SLOPE |

SECTION DESIGNATION — SECTION NAME

(A/X) **SECTION CUT**

SCALE: NTS

DRAWING OF ORIGIN — SCALE

DETAIL NO — DETAIL NAME

(1/X) **DETAIL DESCRIPTION**

SCALE: NTS

DRAWING OF ORIGIN — SCALE

## MATERIAL LEGEND

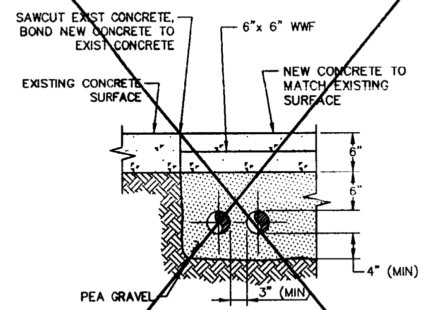
- ASPHALT
- BENTONITE
- BENTONITE/CEMENT GROUT
- BENTONITE PELLETS
- BUILDING (EXISTING)
- COMPACTED BACKFILL
- COMPACTED BASE STONE
- CONCRETE
- PEA GRAVEL
- SAND
- UNDISTURBED SOIL

## PIPE MATERIAL

| | |
|---|---|
| CS | CARBON STEEL |
| GALV | GALVANIZED STEEL |
| PVC | POLYVINYL CHLORIDE |
| SPVC | SCREENED POLYVINYL CHLORIDE |

## PIPE SERVICE

| | |
|---|---|
| AIJ | AIR INJECTION |
| BIV | BIOVENTING |
| DR | DRAIN |




(1/–) CONCRETE REPLACEMENT DETAIL

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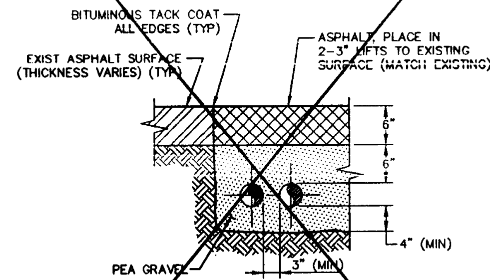


(2/–) ASPHALT REPLACEMENT DETAIL

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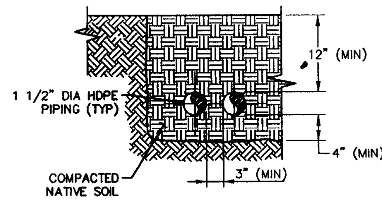


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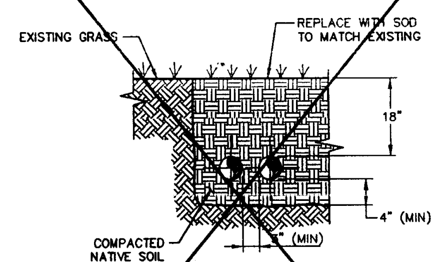


(–) GRASS COVER REPLACEMENT DETAIL

SCALE: NTS

| Rev. | Date | Description | By |
|---|---|---|---|
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Job No. 726876.28242
Designed RAF
Drawn MW
Checked
Reviewed
Approved
Reg No.
Date

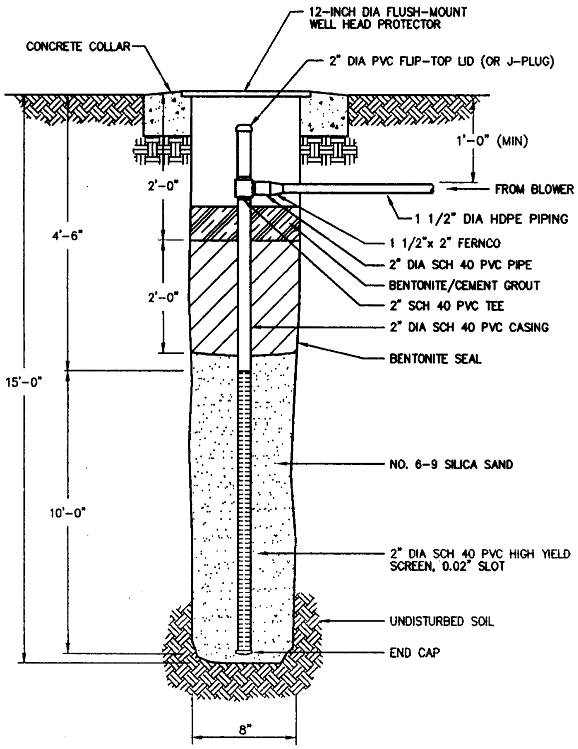
**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado (303) 831-8100

**AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)**

EXPANDED BIOVENTING SYSTEM
SITE SS-41
CHARLESTON AIR FORCE BASE

**LEGEND AND STANDARD TRENCH DETAILS**

DRAWING NO G-0.2 | REV A




1 VENT WELL (VW) DETAIL

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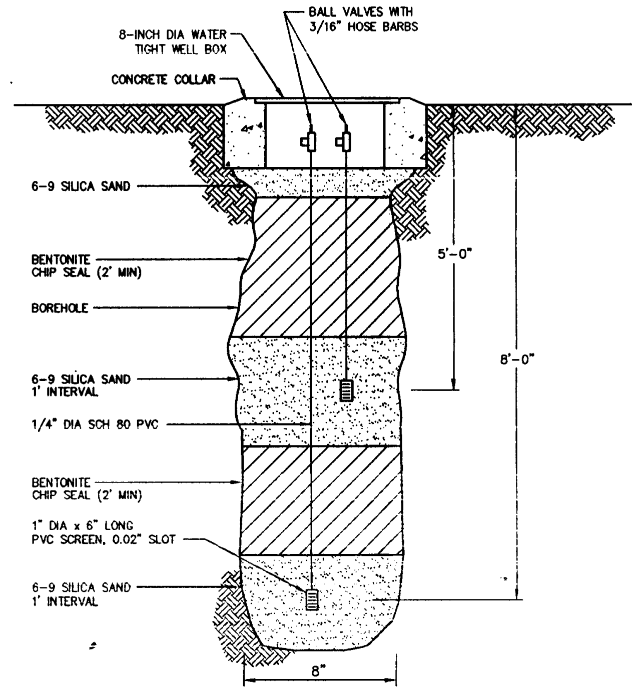


2 MONITORING POINT (MP) DETAIL

SCALE: NTS

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| Job No. 726876.26242 | |
| Designed | RAF |
| Drawn | JH |
| Checked | 7/24/96 |
| Reviewed | 7/26/96 |
| Approved | 7/25/96 |
| Reg No | |
| A | 7/19/96 65% DESIGN |
| Date / Rev / Date / Description / By | |

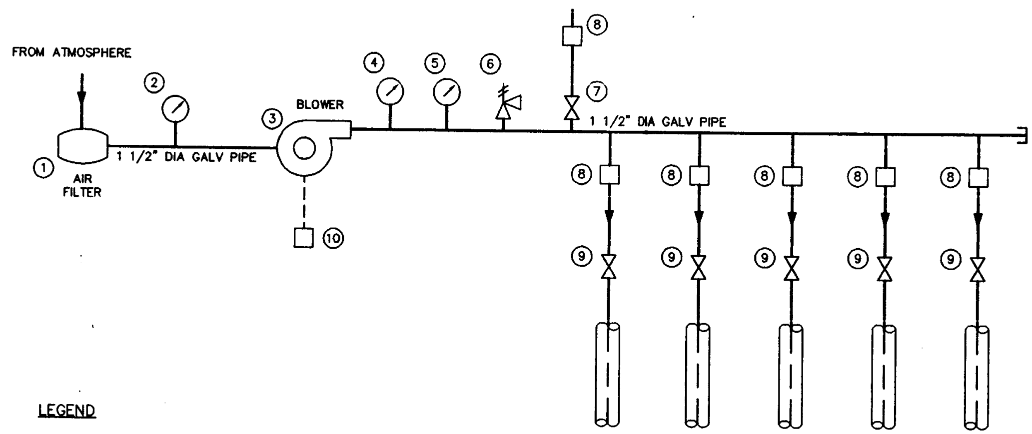
PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

EXPANDED BIOVENTING SYSTEM
SITE SS-41
CHARLESTON AIR FORCE BASE

VENT WELL AND MONITORING POINT STANDARD DETAILS

DRAWING NO G-0.3 REV A




LEGEND

1. INLET AIR FILTER – SOLBERG F-30P-150, REPLACEMENT ELEMENT 30P
2. VACUUM GAUGE –GAST® AJ497, 2 1/2" DIA, 0–60" $H_2O$, 1/4" NPT, LM
3. BLOWER – GAST® 2.0HP R5325R-50, 100 CFM AT 50" $H_2O$ PRESSURE
4. TEMPERATURE GAUGE – ASHCROFT, 0–250°F, 1/2" NPT, CBM (Part No. 2A606 FROM GRAINGER)
5. PRESSURE GAUGE – WIKA 611.10, 2 1/2" DIA., 0–100" $H_2O$, 1/4" NPT, LM (Part No. 9851810)
6. AUTOMATIC PRESSURE RELIEF VALVE – GAST® AG258, SET TO RELEASE AT 60" $H_2O$ PRESSURE
7. MANUAL PRESSURE RELIEF (BLEED) VALVE – 1 1/2" GATE
8. FLOW MEASURING PORT FITTED WITH PLUG (1/4" x 1/8" NPT BRASS REDUCING BUSHING, 1/8" NPT BRASS PLUG)
9. FLOW CONTROL VALVE – 1 1/2" GATE
10. DISCONNECT SWITCH

## 1 BLOWER PIPING AND INSTRUMENTATION DIAGRAM

SCALE: NTS

| | | |
|---|---|---|
| Job No. 726876.28242 | | |
| Designed RAF | | |
| Drawn MW | | |
| Checked | 7/24/96 | |
| Reviewed | 7/24/96 | |
| Approved | 7/23/96 | |
| Reg No | A 7/19/96 | 65% DESIGN |
| Date | Rev Date | Description By |

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AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)
EXPANDED BIOVENTING SYSTEM
SITE SS-4
CHARLESTON AIR FORCE BASE

BLOWER P & ID

DRAWING NO G-0.4 REV A

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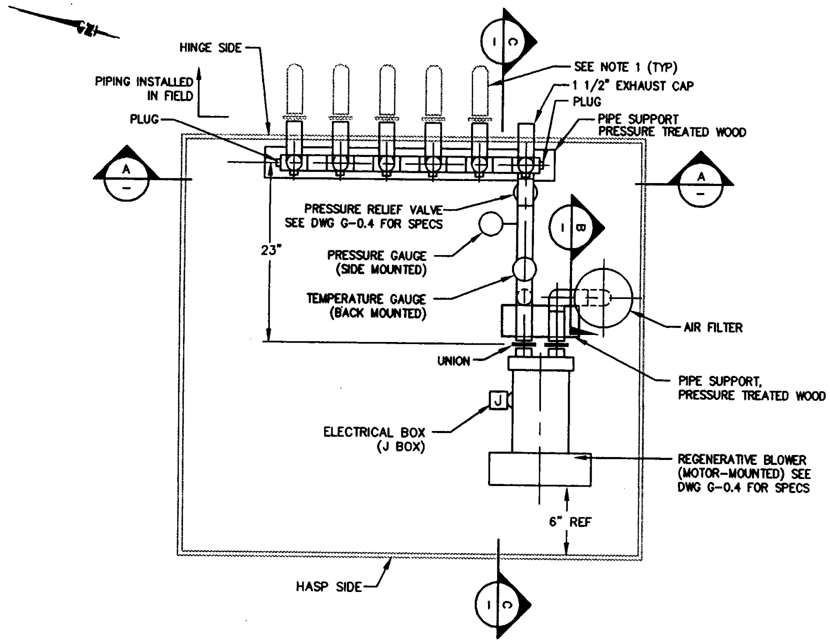
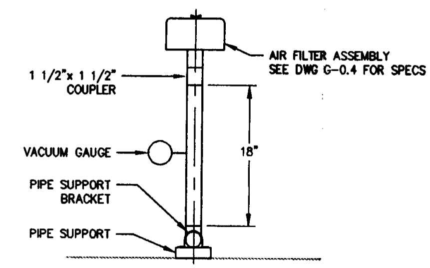



1 BLOWER PIPING LAYOUT PLAN DETAIL (TYPICAL OF TWO)

3/4" = 1'-0"

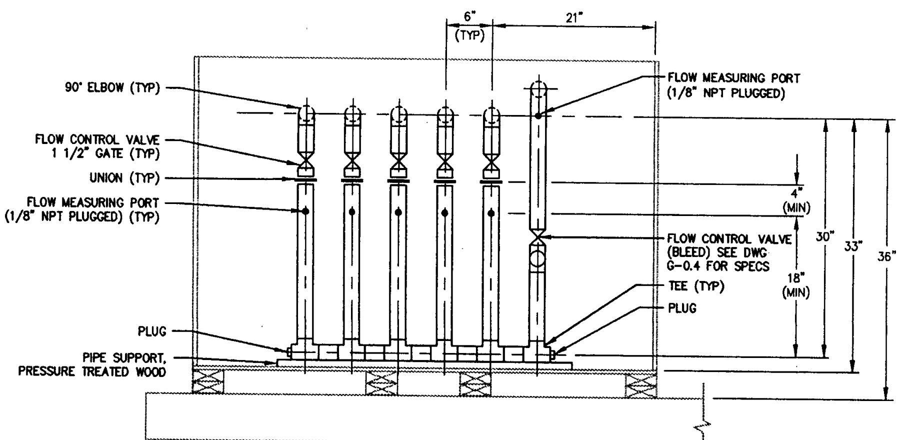
NOTES:

1. SHOP CORE HOLES TO PIPING DIMENSIONS
2. ALL PIPING 1 1/2" DIA. GALVANIZED STEEL, UNLESS OTHERWISE NOTED
3. SEE DRAWING G-0.6 FOR BLOWER BUILDING DETAILS
4. PROVIDE 24" MIN CLEARANCE BETWEEN BLOWER SHEDS



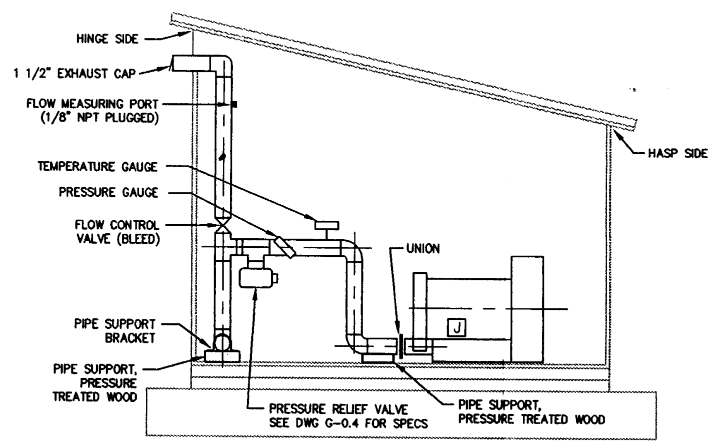

B BLOWER INLET PIPING SECTION

3/4" = 1'-0"




A MANIFOLD DETAIL SECTION

3/4" = 1'-0"




C BLOWER OUTLET PIPING SECTION

3/4" = 1'-0"

| | |
|---|---|
| Job No. 726876.28242 | |
| Designed RAF | |
| Drawn MW | |
| Checked | 7/25/96 |
| Reviewed | 7/26/96 |
| Approved | 7/26/96 |
| Reg No | |
| Date | |

| Rev | Date | Description | By |
|---|---|---|---|
| A | 7/19/96 | 65% DESIGN | |

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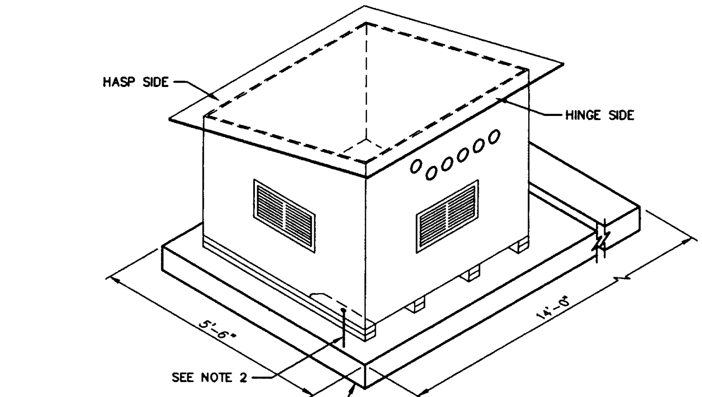
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)

EXPANDED BIOVENTING SYSTEM
SITE SS-41
CHARLESTON AIR FORCE BASE

BLOWER PIPING LAYOUT DETAIL

DRAWING NO G-0.5 REV A

K:\AFCEE\726876\CHRLSTON\96DN0559. 07/24/96 at 15:18

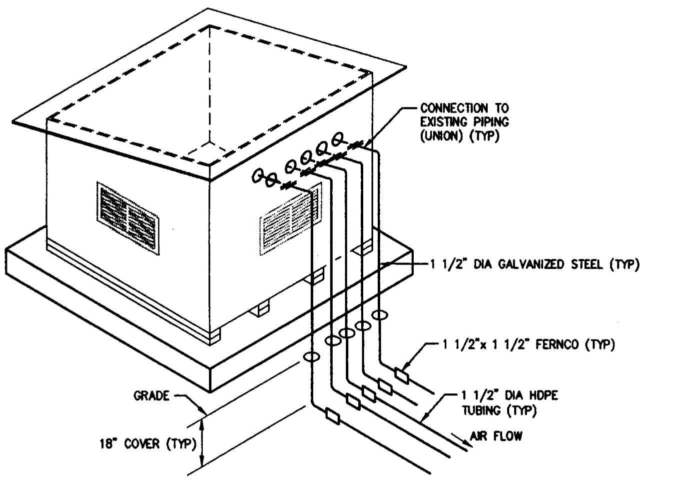



NOTES:

1. FIELD INSTALL BUILDING CENTRAL ON CONCRETE SLAB WITH ORIENTATION AS SHOWN
2. FIELD SECURE BLOWER SHED TO CONCRETE SLAB AT LOCATIONS BY THRU BOLTING. USE 3/8"x 6" LONG ST STL WEDGE ANCHOR BOLTS

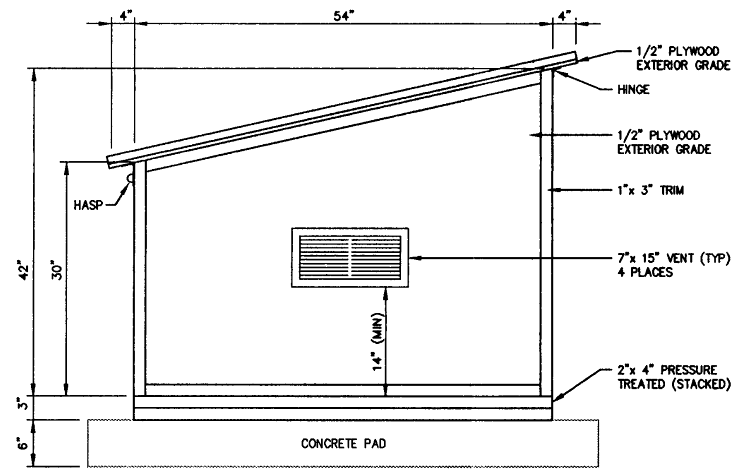
## 1 BLOWER SHED FIELD INSTALLATION DETAIL

NOT TO SCALE

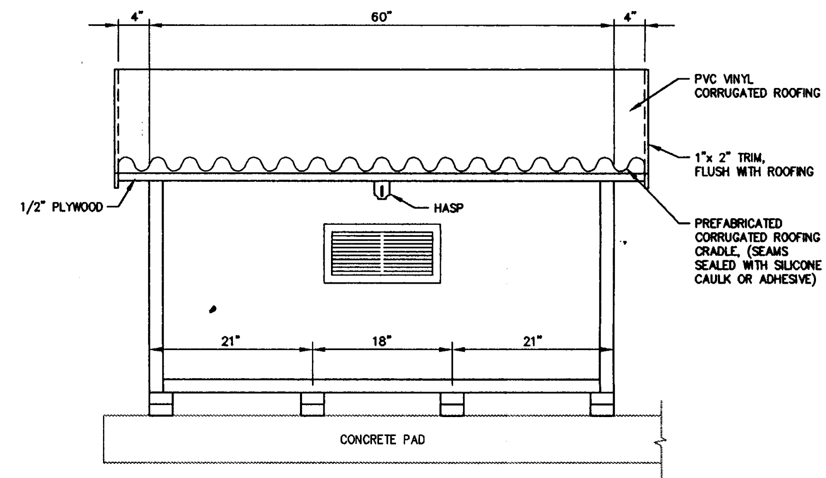



## 2 TYPICAL MANIFOLD DISCHARGE PIPING LAYOUT

NOT TO SCALE




## SIDE ELEVATION




## FRONT ELEVATION

NOTES:

1. 2"x 2" FRAME CONSTRUCTION
2. FLOOR CONSTRUCTED OF 3/4" EXTERIOR GRADE PLYWOOD
3. ROOF CONSTRUCTED OF 1/2" EXTERIOR GRADE PLYWOOD COVERED WITH PVC VINYL CORRUGATED ROOFING

## 3 BLOWER SHED CONSTRUCTION DETAIL

3/4" = 1'-0"

| | | | | |
|---|---|---|---|---|
| Job No. 726876.28242 | | | | |
| Designed RAF | | | | |
| Drawn MW | | | | |
| Checked | 7/24/96 | | | |
| Reviewed | 7/26/96 | | | |
| Approved | 7/26/96 | | | |
| Reg No | A | 7/19/96 | 65% DESIGN | |
| Date | Rev | Date | Description | By |

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado (303) 831-8100

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE (AFCEE)
EXPANDED BIOVENTING SYSTEM
SITE SS-41
CHARLESTON AIR FORCE BASE

BLOWER SHED FIELD INSTALLATION DETAIL AND BLOWER SHED CONSTRUCTION DETAILS

DRAWING NO G-0.6 | REV A

K:\AFCEE\726876\CHRLSTON\96DN0560, 07/24/96 at 15:35

# APPENDIX B

# REGULATORY COMMENTS AND RESPONSE TO COMMENTS

South Carolina
DHEC
Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201-1708



Mr. Al E. Urrutia
437 CES/CEVR
100 W. Stewart Avenue
Charleston AFB, SC 29404-4827

Re: Corrective Action Plan/Expanded Bioventing System
dated November 1996, received January 7, 1997
Former Fuel Pumping Station #3, Bldg. 93 (Site Identification # 15791)
Charleston AFB, SC
Charleston County

Date: February 12, 1997

Dear Mr. Urrutia:

The author has completed technical review of the referenced document. As submitted, the plan provides results of previously conducted Bioventing Pilot Test and proposes to expand the existing system for long term implementation as the primary remedial activity for the referenced site. Specifically, application has been made for construction of nine (9) air injection vent wells (VW) and installation of nine (9) additional vapor monitoring points (VMP) at the site. Approval for construction of the VW has been issued under UIC Permit # 148M, dated February 4, 1997. Based on the foregoing review, the following comments are provided for your consideration:

- Appropriate groundwater monitoring should be conducted, including initial sampling(s) performed prior to system start-up (baseline data) and (at a minimum) every six (6) months thereafter during operation. Closure groundwater sampling will be required in conjunction with proposed closure soil sampling(s). Additional groundwater sampling(s) will be required in the long term (post closure) to verify the system's effectiveness (i.e. six [6] months subsequent to shutdown and one [1] year subsequent to shutdown). Groundwater samples should be analyzed for BTEX and PAH constituents, utilizing appropriate methodologies and detection limits sufficient to demonstrate compliance with the State's Water Classifications and Standards and Primary Drinking Water Standards.

- Appropriate reports should be developed incorporating groundwater sampling data, soil sampling data (as available) and system maintenance/monitoring records. These reports should be submitted to my attention subsequent to start-up and every six (6) months thereafter during operation. Appropriate notification should be provided to the Department (my attention) during each major event which requires extended shutdown of the system.

Provided the above comments are appropriately addressed, the proposed plan is approved for implementation. An addendum which provides an appropriate groundwater monitoring strategy (as outlined above) and reporting schedule should be submitted to my attention no less than thirty (30) days prior to system start-up.

Should you have any questions please contact me at (803) 734-5328.

Sincerely,

Paul L. Bristol, Hydrogeologist
Groundwater Assessment and Development Section
Bureau of Water

cc: Trident District EQC

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 437TH AIRLIFT WING (AMC)

U.S. AIR FORCE
1947 - 1997

437 CES/CEVR
100 W. Stewart Avenue
Charleston AFB SC 29404-4827

Groundwater Assessment and Development Section
Bureau of Water (Attn: Mr. Paul Bristol)
2600 Bull Street
Columbia, SC 29201

Re: Response to Comments Regarding the Bioventing Pilot Test at the Former Fuel Pumping Station Bldg. 93 (Groundwater Protection Division Site # 15791), Installation Restoration Program (IRP) Site SS-41 - Reference Your Letter Dated 12 Feb 1997

Dear Mr. Bristol,

The purpose of this memo is to respond to your comments and summarize our conversation of 19 Feb 1997 at 1:45 pm. Your comments and our responses are provided at the attachment. Included within that attachment are the four wells that will be sampled for groundwater plus a site sketch showing the locations of those wells.

Again, please note that the start-up of the system is six to eight weeks away. Fieldwork to construct the system is scheduled to begin on Monday, February 24, 1997. Based on our February 19, 1997 telephone conversation, fieldwork will begin as scheduled on that date. Both Mr. Rob Devlin and you will be notified of system construction completion and the expected start-up date as soon as they become known to this office.

If you have any questions about this matter, please contact Mr. Keith Thompson, Mr. Bo Camp or myself at (803) 566-4976.

AL E. URRUTIA
Restoration Program Manager

Atch:
Response to Comments

[redacted]

Comment:
Appropriate groundwater monitoring should be conducted, including initial sampling(s) performed prior to system start-up (baseline data) and (at a minimum) every six (6) months thereafter during operation. Closure groundwater sampling will be required in conjunction with proposed closure soil sampling(s). Additional groundwater sampling(s) will be required in the long term (post closure) to verify the system's effectiveness (i.e. six months subsequent to shutdown and one year subsequent to shutdown). Groundwater samples should be analyzed for BTEX and PAH constituents, utilizing appropriate methodologies and detection limits sufficient to demonstrate compliance with the State's Water Classification and Standards and Primary Drinking Water Standards.

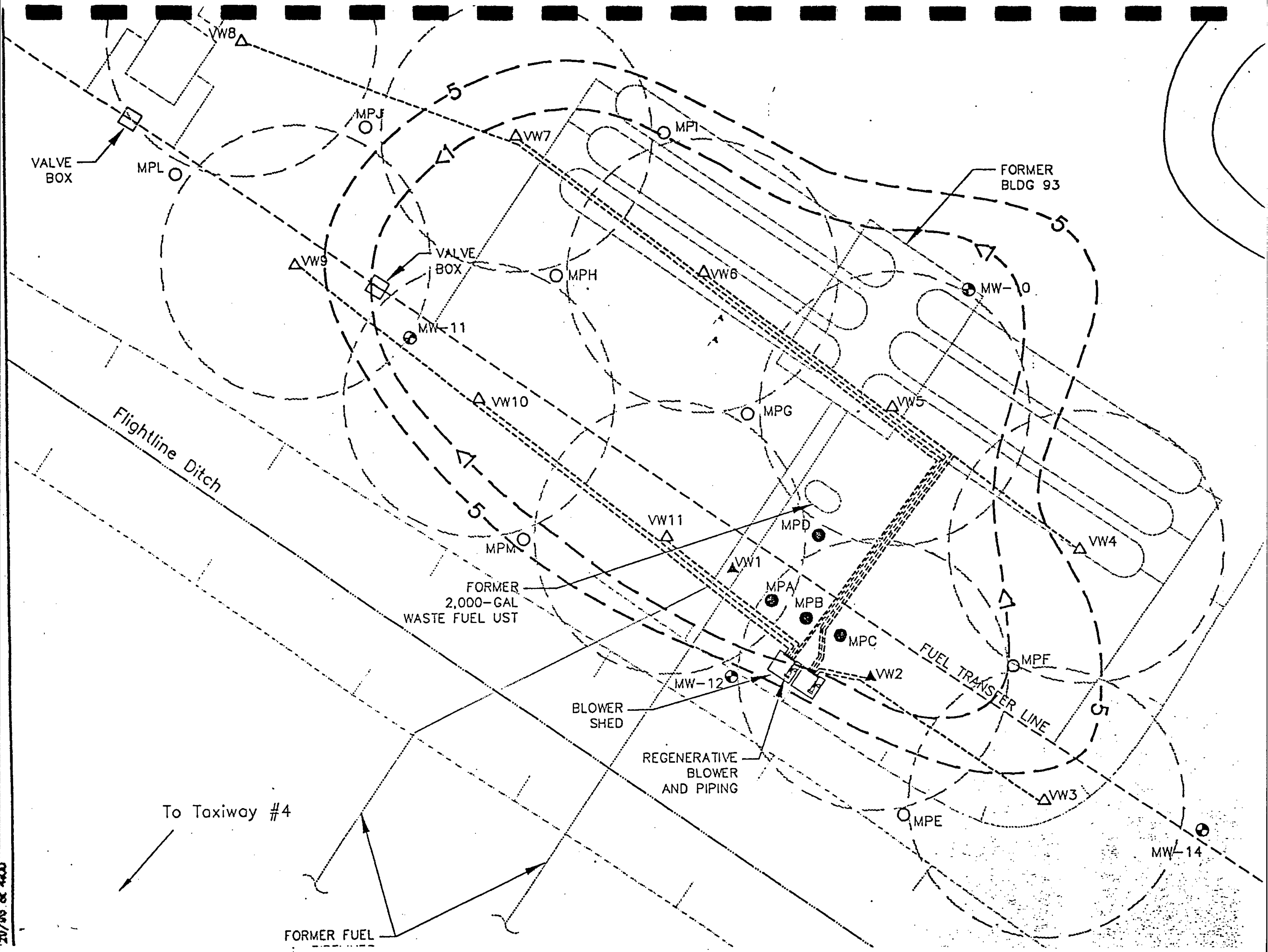
**Response:**
**The Air Force Center For Environmental Excellence (AFCEE) is sponsoring, funding and managing this project through their Research and Development (R&D) section. Charleston AFB is not funding this project, nor is it providing any additional funds to conduct the bioventing pilot test. The AFCEE point of contact was consulted to determine whether or not funds were available to conduct groundwater and soil sampling at the six month interval. AFCEE's response was that funds are available to conduct pre-start-up groundwater analysis in order to establish baseline data. Additionally, funds are also available to conduct post closure analysis to verify the system's effectiveness at the end of one year. However, there are no funds available to conduct the six month groundwater or soil analysis. The groundwater samples will be analyzed for BTEX and PAH constituents utilizing the appropriate methodologies. Request you consider waiving the six month groundwater analysis as agreed to in our telephone conversation of 19 Feb 1997.**

Comment:
Appropriate reports should be developed incorporating groundwater sampling data, soil sampling data (as available) and system maintenance/monitoring records. These reports should be submitted to my attention subsequent to start-up and very six months thereafter during operation. Appropriate notification should be provided to the Department (my attention) during each major event which requires extended shutdown of the system.

**Response:**
**As discussed during our telephone conversation and the above mentioned comment/response, funds are not available to conduct six month sampling of groundwater or soils. Therefore, we cannot produce a six month report. However, start-up reports and post closure reports will be submitted to your attention. Additionally, the Department (your office) will be notified of each major event which requires extended shutdown of the system.**

Comment:
Which groundwater wells will be sampled?

**Response:**
**Please refer to Figure 4.1 on page 4-4. Also, see the sketch that is provided as part of this attachment. Groundwater monitoring wells MW-10, MW-11, MW-12 and MW-14 are proposed for groundwater analysis.**


VW8
VALVE BOX
MPL
MPJ
VW7
MPI
FORMER BLDG 93
5
VW9
VALVE BOX
MPH
VW6
MW-10
MW-11
VW10
MPG
VW5
Flightline Ditch
VW11
MPD
VW4
MPM
VW1
FORMER 2,000-GAL WASTE FUEL UST
MPA
MPB
MPC
FUEL TRANSFER LINE
MPF
VW2
MW-12
BLOWER SHED
REGENERATIVE BLOWER AND PIPING
VW3
MPE
MW-14
To Taxiway #4
FORMER FUEL

South Carolina
DHEC
Department of Health and Environmental Control
2600 Bull Street, Columbia, SC 29201-1708



Mr. Al E. Urrutia
437 CES/CEVR
100 W. Stewart Avenue
Charleston AFB, SC 29404-4827

Re: Corrective Action Plan/Expanded Bioventing System Response to Comments received February 24, 1997
Former Fuel Pumping Station #3, Bldg. 93 (DHEC Site Identification # 15791)
Charleston Air Force Base
Charleston AFB, SC
Charleston County

Date: March 19, 1997

Dear Mr. Urrutia:

The author has completed technical review of the referenced document. Based on the information provided, the author concurs with the proposed sampling plan and reporting schedule. It is anticipated that all activities and reporting requirements for the Corrective Action Plan dated November 1996 will continue as previously approved.

Should you have any questions please contact me at (803) 734-5328.

Sincerely,

Paul L. Bristol

Paul L. Bristol, Hydrogeologist
Groundwater Assessment and Development Section
Bureau of Water

cc: Trident District EQC